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HARDMAN III UTILITY ASSESSMENT ANALYSIS

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The contractor evaluated the Hardware versus Manpower (HARDMAN) III in performing a Cost and Operational Effectiveness Analyses including assessing the workload required to qualify an analyst, its usefulness in completing an accurate manpower, personnel and training (MPT) analysis and determining the required hardware and software modifications.

CONCLUSIONS

1. **The HARDMAN III was developed without performing a needs analysis, identifying the target analytical audience and performing periodic assessments to avoid people problems.**

2. **HARDMAN III is difficult for the MPT analyst to create a baseline comparison system.**

3. **The 3 day training seminar does not qualify an individual to conduct a HARDMAN III analysis using the software.**

4. **The HARDMAN III software contains numerous inconsistencies such as an absence of technical specifications; poor user friendliness and an understatement of the database and hardware requirements.**

5. **Project A is obsolete and needs to be updated since the data reflects soldier capabilities going back to the early 1980's.**

RECOMMENDATIONS

1. **Sponsorship of the HARDMAN III software by TRADOC is not recommended because the costs outweigh the benefits.**

2. **The Army Research Laboratory should develop a Computer Based Training tutorial to train HARDMAN III analysts, salvage the best modules, scrap T-CON and consolidate the various databases into a single library.**

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FINAL
TECHNICAL REPORT

HARDMAN III
Utility Assessment
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ABSTRACT

The purpose of this project was to make an assessment of the utility of the Hardware versus Manpower (HARDMAN) III in performing a Cost and Operational Effectiveness Analyses (COEA). The statement of work required the contractor to perform the following tasks: (1) conduct an assessment of the workload required to qualify an analyst and maintain his/her proficiency in applying the HARDMAN III including the workload required for standardization and configuration control of the software; (2) evaluate the HARDMAN III's usefulness to complete an accurate manpower, personnel and training (MPT) analysis in support of a COEA for TRADOC agencies; and (3) determine the required hardware and software modifications needed to improve the HARDMAN III's utility.

<u>CONCLUSIONS</u>

1. The HARDMAN III software was developed and acquired without adhering to the following key manpower and personnel integration (MANPRINT) concepts: (1) performing a needs analysis of what the ultimate user wants and needs to perform an accurate MPT analyses; (2) identifying the target analytical audience; and (3) performing periodic MANPRINT assessments to preclude people problems (e.g., user friendliness) from appearing in the software development. The title "HARDMAN III" software is a misnomer since several of the six modules do not enable an MPT analyst to calculate a materiel system's MPT resource requirements data that previously could be determined using the HARDMAN Comparative Methodology (HCM). In summary, it appears that there was a lack of intended user involvement in the design phase.

2. HARDMAN III is difficult for the MPT analyst to create a baseline comparison system (BCS) (a key step in the HCM methodology). HARDMAN III does not have the capability for an analyst to perform a Training Resource Requirements Analysis and produce the myriad of training products for each training course such as annual student inputs, instructor manpower requirements and course costs.

3. The three-day training seminar provides the analyst with a familiarization and the basic rudiments of HARDMAN III but does **not** qualify an individual to conduct a HARDMAN III analysis using the software. The HARDMAN III training seminar was not designed, developed nor conducted in accordance with the systems approach to training (SAT) as contained in Military Standard (MIL-STD) 1379D.

4. The COEA is considered as the vehicle for centralized MPT analyses within TRADOC. As an integrating document, the COEA frequently addresses new concepts requiring databases from non-traditional sources (e.g., contractor or other DOD service maintenance data) that HARDMAN III is unable to provide. However, databases can be built using HARDMAN III resources permitting. Additional COEA incompatibilities with HARDMAN III that were detected included: (a) HARDMAN III flow models break Reliability, Availability and Maintainability (RAM) data into individual missions while the Armored Gun System (AGS) COEA uses annualized data; (b) the difficulty by which HARDMAN III can accommodate MPT requirements for several alternatives, in addition to the base case, often required of COEA study plans.

5. Our assessment of the HARDMAN III software detected numerous nuisances including: an absence of technical specifications; poor user friendliness; and an understatement of the database and hardware requirements to operate the HARDMAN III software. The HARDMAN III software lacks compliance with DOD-STD-2167A, "Defense System Software Development." The inconsistencies are discussed in Section 4. In summary, it appears that there was a lack of centralized database design as well as adequate reference documentation.

6. Project A, used to assess personnel performance in several of the HARDMAN III modules, appears to be obsolete and needs to be updated since the Armed Services Vocational Aptitude Battery (ASVAB) data reflects soldier capabilities going back to the early 1980's.

<u>RECOMMENDATIONS</u>

1. Acceptance or sponsorship of the HARDMAN III software by TRADOC is not recommended because of the following: (a) operating and maintaining the HARDMAN III is too costly in terms of man-hours per year required for configuration control, software standardization, data base updates, and additional computer hardware necessary to accommodate future growth in the modules; (b) the value for TRADOC school Directorate of Combat Development (DCD) and Directorate of Training Development (DOTD) MPT analysts is questionable.

2. The Army Research Laboratory (ARL) should consider developing a Computer Based Training (CBT) tutorial to train prospective analysts (outside TRADOC) in HARDMAN III. An improved tutorial integrated into the software modules would be a significant improvement and should replace the three-day seminar.

3. Assuming improvements are made to HARDMAN III, ARL should salvage the best modules, scrap T-CON and consolidate the various databases into a single library that would rectify many of the inconsistencies inherent in HARDMAN III. There should be universal linkages among modules to facilitate the transfer of data. If consolidations are not made among the modules, recommend improving the module linkages. ARL should develop personnel selection criteria for both military and Department of the Army civilian analysts for selection as HARDMAN III analysts.

SECTION 1.0
INTRODUCTION

1.0 INTRODUCTION

The HARDMAN III Project was initiated by the Army Research Institute (ARI) to resolve analytic deficiencies of previous methods (see **Table 1-1**) and accomplish three objectives: (1) influence system design to improve accommodation of projected MPT constraints; (2) evaluate materiel systems in development to determine MPT requirements for acceptable system performance and availability; and (3) enhance the tools and techniques available to manpower and personnel integration (MANPRINT) practitioners. The HARDMAN III decision support system developed by the ARL, Human Research and Engineering Directorate (HRED) is an attempt to satisfy the need for integrated analytical tools using a new conceptual base. The concept involves defining MPT constraints for a developing system and assessing the impact of these constraints on human task performance and overall system performance before design is begun. Design features, which include ease of iteration, personal computer (PC)-based, and built-in data libraries, make it a promising capability for MANPRINT analysts.

1.1 HARDMAN III Description. (The remainder of this chapter, including figures and tables, is from: MANPRINT - An Approach to Systems Integration, Edited by Dr. Harold R. Booher, Chapter 12: MANPRINT Tools and Techniques, dated 1990.)

The HARDMAN III software consists of six independent but mutually supporting modules (see **Figure 1-1**):

1.1.1 <u>SPARC (System Performance and RAM Criterion Estimation Aid) Module</u>. SPARC aids the user in decomposing a mission description into functions and subfunctions and then provides system performance criteria (e.g., time, accuracy) at the subfunction level required to meet mission criteria. SPARC sets the minimum acceptable system performance requirements and specifies the reliability, availability, and maintainability (RAM) requirements for the system at the subsystem level. SPARC enables hardware and software designers to know what the manned system will have to do in order to be minimally acceptable.

1.1.2 <u>M-CON (Manpower Constraints Aid) Module</u>. M-CON provides an estimate of the Army-wide and per system manpower that is likely to be available to support a developing system. Use of this module involves setting manpower constraints, evaluating the sensitivity of the system performance to these constraints, and adjusting as necessary. M-CON addresses quantitative manpower constraints for maximum crew sizes by system and total operator and maintenance manpower available at pay grade, military occupational specialty (MOS), and maintenance organizational

TABLE 1 - 1
Common Limitations of MPT Analytic Techniques

Sensitivity:

Lack measures of sensitivity to mission and operational scenarios.

Hardware Dependence:

Require predecessor systems for system comparisons of similarity.

Most methods do not apply to classes of system (e.g., armored vehicle, air defense systems, communication equipment).

Data:

Lack necessary data support to influence early decisions in the materiel acquisition process.

Flexibility:

Do not provide sufficient parameter ranges for MANPRINT domain impact; limited ability to conduct "what ifs."

Cost:

Too costly and too cumbersome (requiring time, manpower, dollars, and large DEC/VAX mainframe computers to conduct analyses).

Source: Booher, Harold R. and Glen M. Hewitt, 1990 "MANPRINT Tools and Techniques." In Harold R. Booher, ed., *MANPRINT: An Approach to Systems Integration.* New York: Van Nostrand Reinhold, p. 371.

Hardware and Manpower (HARDMAN) III Analysis

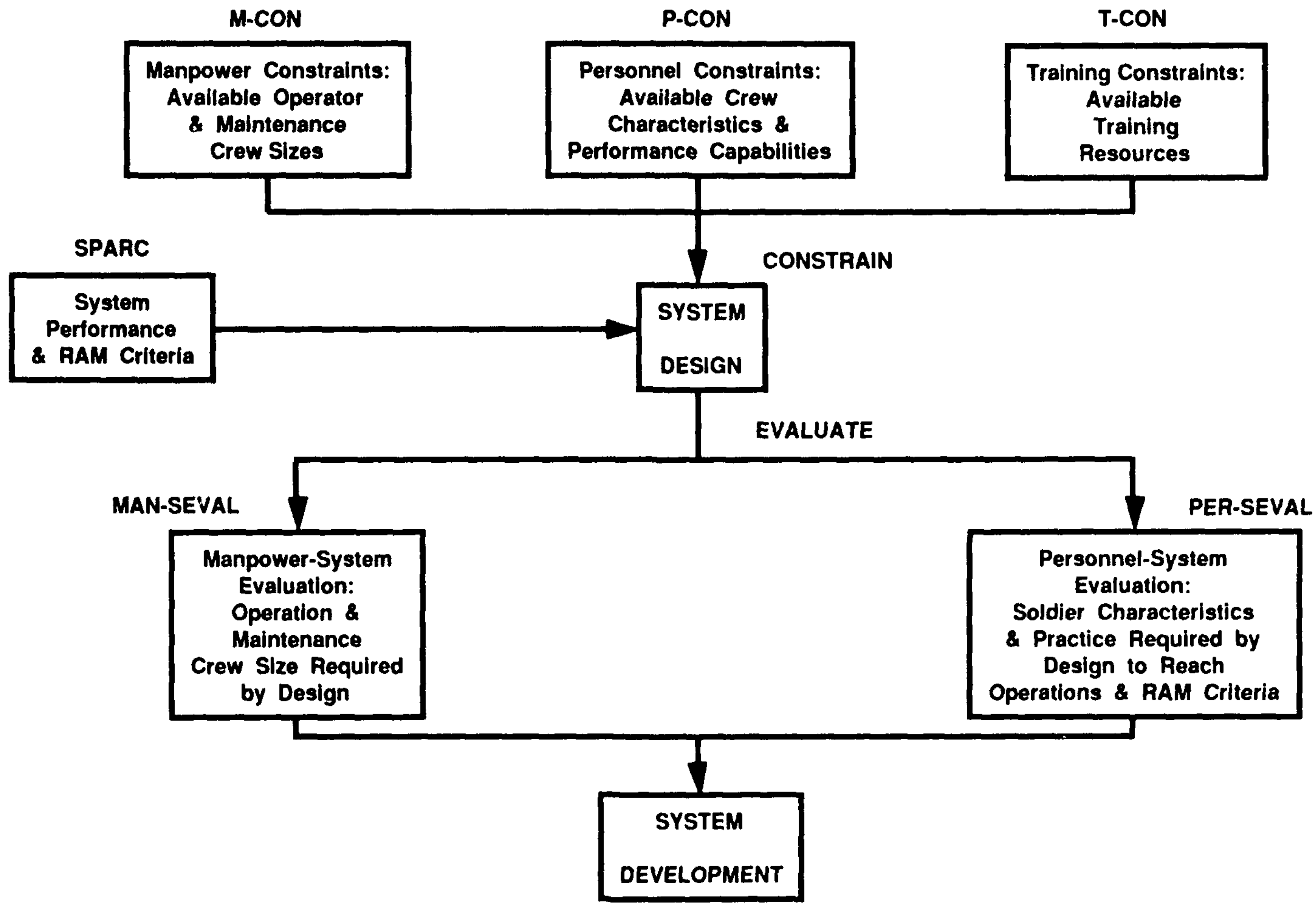


Figure 1 - 1

Source: See Table 1 - 1

level of detail (e.g., direct support, general support). M-CON outputs are based on manpower availability predictions of the MOS due to replacement of systems already in the force.

1.1.3 P-CON (Personnel Constraints Aid) Module. P-CON provides an estimate of personnel aptitude constraints. Distribution of personnel characteristics (e.g., armed forces entrance test scores, education, language levels, and gender) is displayed for operations and maintenance crews projected for future years. P-CON gives the performance expected at the task level based on Project A database (see **Table 1-2**) and the MOS cutoff score required for criterion performance. This tool aids in predicting the availability of soldiers with desired abilities and relates these characteristics to soldier performance.

1.1.4 T-CON (Training Constraints Estimation Aid) Module. T-CON (according to the contractor-Applied Science Associates) is a tool used for early estimation of the training burd^n associated with a new materiel system. T-CON employs a database of training data to estimate operator training, on a function-by-function basis, and maintainer training, on a subsystem-by-subsystem basis. To use T-CON, the user begins with a model that defines functions and subsystems. This model can then be tailored to more closely fit the user's intent. The training estimate is developed by the T-CON software by extracting from the database the training associated with real Army systems for specific functions and subsystems.

1.1.5 MAN-SEVAL (Manpower-Based System Evaluation Aid) Module. MAN-SEVAL evaluates the quantitative manpower requirements at the completion of the system design phase and prior to the development of any system prototypes. MAN-SEVAL identifies the jobs associated with each design and the tasks, the number of operators and maintainers, and the occupational specialty and skill level associated with each job. MAN-SEVAL deals with operator manpower through a combination of modeling and workload analysis. It deals with maintainer manpower by modeling the relationship between maintenance manpower and system availability. It allows the analyst to determine manpower requirements and compare them to manpower availability.

1.1.6 PER-SEVAL (Personnel-Based System Evaluation Aid) Module. PER-SEVAL assists analysts in identifying the aptitudes of personnel needed to support a particular design. It enables the analyst to evaluate the human element of materiel systems by identifying the level of personnel characteristics needed to meet design system performance requirements with fixed amounts of training under the specific conditions in which the system tasks will be performed. The components of PER-SEVAL according to the Concepts on MPT Estimation Final Report (see Appendix B) include the following: (1) performance shaping functions that predict performance as a function of personnel characteristics and training; (2) stressor algorithms that

TABLE 1 - 2
Project A Data Support of HARDMAN III

Project A is a research data collection effort by the Army Research Institute (ARI) that has produced a longitudinal data base matching Armed Services Vocational Aptitude Battery (ASVAB) test scores with job performances for 10,000-15,000 individuals.

HARDMAN III uses the data to predict task performance of the available soldier population, the effects of operating and maintaining weapons systems with varying quality of soldiers, and soldier aptitude requirements for existing, developing, and non-developmental item (NDI) systems.

Source: Development and Field Test of the Trial Battery for Project A, May 1987, produced by the U.S. Army Research Institute degrade performance to reflect the presence of critical environmental stressors; and (3) operator and maintainer simulation models (using Microsaint logic) that aggregate the performance estimates of individual tasks and produce estimates of system performance. This tool is designed to be used to predict performance of all aptitude levels of soldiers operating or maintaining the system under conditions specified by the user.

1.2 Tool Identification and Selection Factors. For systems integrators faced with identifying and/or evaluating MANPRINT issues in a timely and cost-effective manner, it is important that they have the most appropriate tools available. The tools of the highest quality are those which have sufficient information to answer the users' questions. In addition, they need to be accessible, highly flexible, provide rapid response, and be easy to use. In order for the systems integrator to assess the quality of potential techniques, the quality of the data sources which the tools use would also need to be known. The criteria used to evaluate the cost effectiveness of a MANPRINT tool such as HARDMAN III is as follows:

1.2.1 Tool Existence. There may be any number of instances where a tool does not exist for the practitioner's question. Prior to the HCM and predecessor system comparability analyses, there essentially were no tools which could assess the impact of a system design on future MPT domains. There are currently few techniques categorized as system safety tools. On the other hand, there are a large number of useful operator workload assessment and prediction methodologies. The primary sources for determining tool existence include the authors of the various surveys and investigators at the various government laboratories or contractor and academic facilities.

1.2.2 Tool Accessibility. Gaining a high degree of confidence that a technique is adequately accessible requires consideration of the following: Is the tool available to the general public or is it company proprietary or other otherwise unavailable?

1.2.3 Quality of Content. This is often the most difficult factor to determine. First consider the quality of the source data. Second, the tool itself can be evaluated by (a) its general intent from published descriptions of the tool and (b) its ability to provide the expected information asked for by the user. For example, if a tool is described as appropriate only for engineering and manufacturing development, it probably has low content quality for concept exploration and definition stage issues. Assessments by subject matter experts (SMEs) or past users provide the most dependable means of determining content quality for the new user.

1.2.4 Ability to Interface with Other Tools. There are generally two problems to consider here. First, is the information from the tool designed to interface with other analyses? The interaction with other MANPRINT domains may affect its ability to influence total system performance issues. Second, are there software interface implications? Is the tool operable on a computer system that is generally available? Can the technique communicate with other software to be used during the development of the system?

1.2.5 Ease of Use. The original HCM methodology provides an example of a tool which meets the first three criteria above (paragraphs 1.2.1-1.2.3), and is valuable even though difficult to use. To assure wide application, the tools need the MANPRINT philosophy applied to them as well. Some considerations are:

- Easy use of the information system
- Quick response
- Flexibility to model at different levels of specificity
- Built-in job aids and variable help levels
- Reasonable training time for new users
- Mobility or portability of tool hardware/software

1.2.6 Cost to Operate. Cost can be evaluated against the above criteria in choosing among several alternatives; but in many instances where only one tool is available, cost becomes the sole criterion.

The above criteria are used in the present analysis to evaluate the utility of the HARDMAN III software modules.

SECTION 2.0
TECHNICAL APPROACH

2.0 STATEMENT OF WORK

TRADOC Analysis Command (TRAC) at Fort Benjamin Harrison, Indiana, directed that our work be focused on the following:

(1) Conduct a "mini MPT assessment" of the costs associated with operating and maintaining the HARDMAN III including: (a) the training workload required to qualify and maintain proficiency in the application of HARDMAN III: (b) any manpower required for configuration control/standardization of the software; (C) the type of qualifications needed for the eventual target audience desired; and (4) the best training media and materials needed to train and maintain currency in the software.

(2) Evaluate HARDMAN III's usefulness to complete an accurate MPT analysis in support of TRADOC analysts conducting a COEA for emerging materiel systems.

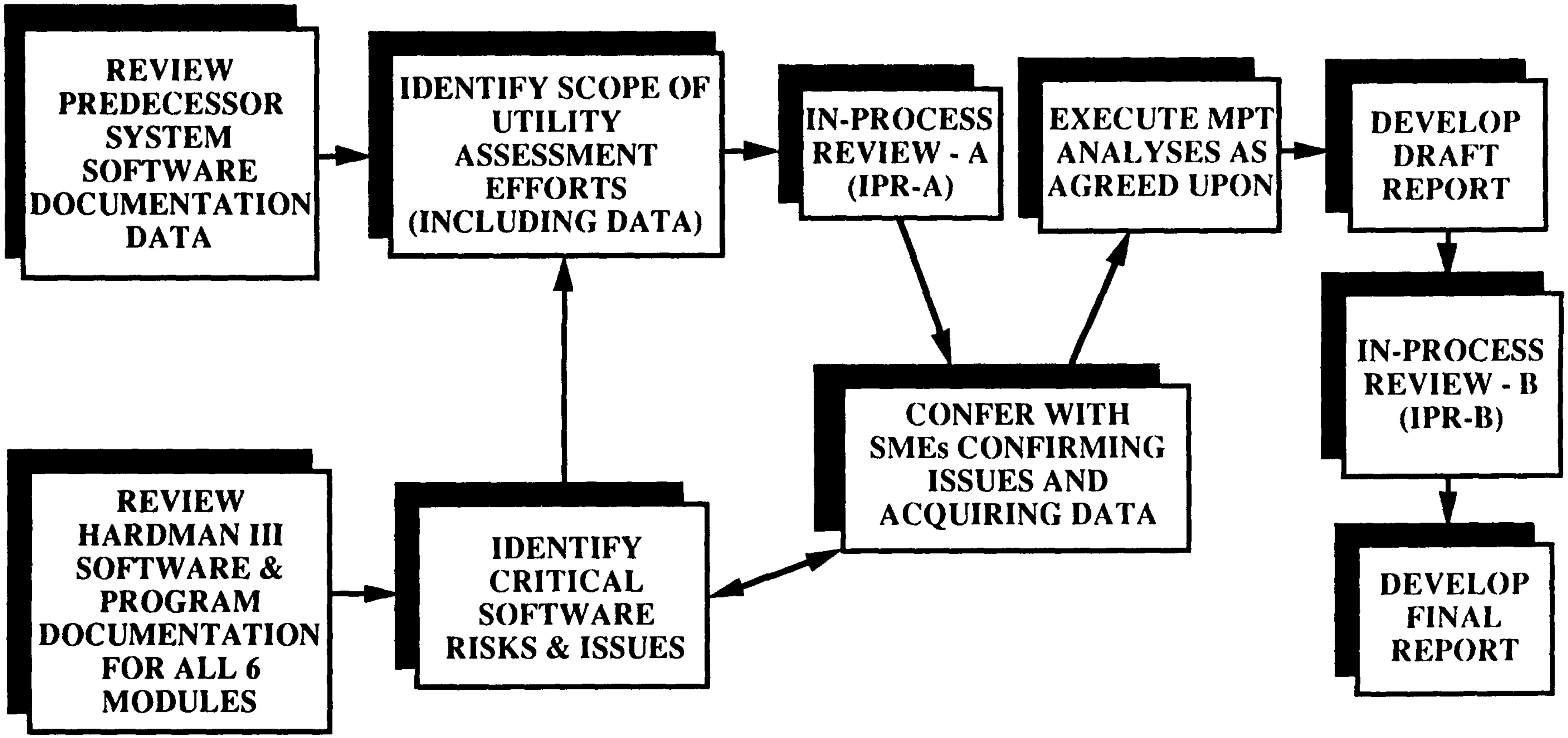
(3) Determine hardware and software modifications needed to improve the HARDMAN III's utility.

2.1 TECHNICAL APPROACH

The technical approach used to evaluate the utility of the HARDMAN III software consisted of the following steps (see **Figure 2-1**): (1) review the HARDMAN III system software and documentation for all six modules; (2) interview and survey selected SMEs and users/developers; (3) attend three-day HARDMAN III training seminar to evaluate the adequacy of the training; (4) verify the HARDMAN III software algorithms by using MPT data from the AGS as trial excursions; (5) determine MPT costs associated with HARDMAN III; (6) recommend modifications or enhancements required of the HARDMAN III software; and (7) provide recommendations on contractor versus in-house centralized or decentralized control of the HARDMAN III software for TRADOC to apply to emerging U.S. Army systems in the materiel acquisition process.

2.1.1 Research of HARDMAN Publications. We reviewed the appropriate HARDMAN III software documentation for each of the six modules. The review included a literature search of HARDMAN II and Man Integrated Systems Technology (MIST) predecessor system documents such as software user's guide, instructor guides, and student study guides, etc. (see **Appendix B** for a complete list of publications and reference materials researched).

HARDMAN III UTILITY ASSESSMENT TECHNICAL APPROACH



Reference: HARDMAN III Utility Statement of Work
Dated 29 May 1992

Figure 2 - 1

2.1.2 Attendance at HARDMAN III Training Seminar. An AEPCO employee attended the three-day training seminar that was conducted by representatives from DRC and MAD from 29 June through 1 July 1992. Additional issues that were discussed with ARL at the training seminar included the cost and licensing of the HARDMAN III software, differences between HARDMAN III versus HARDMAN II, background of Project A database and the software documentation. Questions were asked about the cost effectiveness of the seminar versus the practicality of a self-paced tutorial program (see Section 5 for additional details).

2.1.3 Administration of HARDMAN III Surveys. Selected SMEs from across the Army were surveyed. An attempt was made to achieve a representative sample of potential HARDMAN III users, especially those SMEs who either attended the training seminar or were involved in the evaluation of several "notional systems" performed under ARI sponsorship. In several cases the surveys were tailored to a specific functional area (i.e., SPARC to RAM developers). **Appendix D** contains a blank copy of the HARDMAN III survey.

2.1.4 Evaluation of HARDMAN III Software. The HARDMAN III software (Version 2.0) was evaluated (see Section 3 for evaluation details) for its compliance with DoD-STD-2168, "Defense System Software Quality Program." User friendliness was the paramount criterion used during the HARDMAN III software evaluation.

2.2 DATA SOURCES AND LIMITATIONS

The HARDMAN III utility assessment included the following steps: (1) Discussions with SMEs both within and outside of TRADOC; (2) Administering HARDMAN III surveys (See **Appendix E** for a complete list of HARDMAN III surveyees and their respective responses); and (3) Attendance at the HARDMAN III training seminar. Several SMEs declined to be surveyed because of higher priority workload, personnel turbulence and/or potential conflict of interest.

2.3 OVERVIEW OF PROJECT A

Project A was examined because soldier performance data and characteristics were extracted and inserted in several of the HARDMAN III modules. Project A was a comprehensive long-range research and development program which the U.S. Army undertook to develop an improved personnel selection and classification system for enlisted personnel. The Army's goal was to increase its effectiveness in matching first-tour enlisted manpower requirements with available personnel resources, through the use of new and improved selection/classification tests to validly predict carefully developed measures of job performance. The project sampled from the 675,000-person enlisted personnel system of the Army encompassing several hundred different military occupations.

2.3.1 Project A Background. This research program began in 1980 when ARI started planning the extensive research effort that would be needed to develop the desired system. In 1982, a consortium led by the Human Resources Research Organization (HumRRO), including the American Institutes for Research (AIR) and the Personnel Decisions Research Institute (PDRI), was selected by ARI to undertake the project. The total project utilized the services of 40 to 50 ARI and consortium researchers working collegially in a variety of specialties, such as industrial and organizational psychology, operations research, management science, and computer science.

2.3.2 Project A Objectives. The specific objectives of Project A were to:

(1) Validate existing selection measures against both existing and project-developed criteria. The latter were to include both Army wide job performance measures based on newly developed rating scales and direct hands-on measures of MOS-specific task performance.

(2) Develop and validate new selection and classification measures.

(3) Validate intermediate criteria (e.g., performance in training) as predictors of later criteria (e.g., job performance ratings) so that better informed reassignment and promotion decisions could be made throughout a soldier's career.

(4) Determine the relative utility to the Army of different performance levels across an MOS.

(5) Estimate the relative effectiveness of alternative selection and classification procedures in terms of their validity and utility for making operational selection and classification decisions.

2.3.3 Project A Stages. The research design for the project incorporated three main stages of data collection and analysis in an iterative progression of development, testing, evaluation, and further development of selection/classification instruments (predictors) and measures of job performance (criteria).

(1) In the first phase, data from Army accessions in fiscal years 81 and 82 were evaluated to explore the relationships between the scores of applicants on the ASVAB, and the applicants subsequent performance in training, and their scores on the first-tour Skill Qualification Tests (SQTs).

(2) In the second phase, a concurrent validation design was executed with fiscal year (FY) 83/84 accessions. As part of the preparation for the concurrent validation, a "preliminary battery" of perceptual, spatial, temperament/personality, interest, and biodata predictor measures was assembled and used to test several

thousand soldiers as they entered four MOSs. The data from this "preliminary battery sample" along with information from a large-scale literature review and a set of structured, expert judgments were then used to identify "best bet" measures. These "best bet" measures were developed, pilot tested, and refined. The refined test battery was then field tested to assess reliabilities, "fakeability" (intentionally providing false replies to test questions), practice effects, and so forth. The resulting predictor battery, now called the "Trial Battery," which includes computer - administered perceptual and psychomotor measures, was administered together with a comprehensive set of job performance indices based on job knowledge tests, hands-on job samples, and performance rating measures in the concurrent validation.

(3) In the third phase (the longitudinal validation), all of the measures, refined on the basis of experience in field testing and the concurrent validation, were administered in a true predictive validity design. About 50,000 soldiers across 20 MOSs were included in the FY 86-87 "Experimental Predictor Battery" administration and subsequent first-tour measurement. About 3500 of these soldiers were estimated for availability for second-tour performance measurement in FY 91.

(4) For both the concurrent and longitudinal validations, the sample of MOSs was specially selected as a representative sample of the Army's 250+ entry-level MOSs. The selection was based on an initial clustering of MOSs derived from rated similarities of job content. These MOSs accounted for about 45 percent of Army accessions.

In summary, use of Project A data was an attempt to "piggy back" on the Army's MOS testing program to gather soldier performance data in the interest of cost effectiveness. Although the data was biased toward lower category enlisted accessions experienced during that period of time, it was perceived by ARI that this performance data was better than no data at all.

SECTION 3.0
MANPOWER, PERSONNEL, TRAINING AND SOFTWARE ISSUES

3.1 MANPOWER, PERSONNEL AND TRAINING ISSUES

The HARDMAN III software was developed and acquired in piecemeal fashion using three different contractors. ARL, in its quest to produce a front-end analytical tool, may have overlooked several key elements of the MANPRINT concept. For example, the Deputy Chief of Staff for Personnel Integration (DCSPI), U.S. Total Army Personnel Command (USTAPC) developed a flow chart or "horseblanket" (see **Appendix C**) that illustrates how MANPRINT is incorporated into the acquisition process for the Major Automated Information Systems Review Council (MAISRC). This "horseblanket" provides a quick reference of the MANPRINT actions required during the respective acquisition phases. Although the "horseblanket" was not available when HARDMAN III was developed, the key MANPRINT processes inherent in the "horseblanket" have been espoused since the early 1980's. HARDMAN III was not considered a major acquisition in accordance with the Army Systems Acquisition Review Council (ASARC) criteria. However, several of the crucial MANPRINT steps such as a needs analysis and identifying the target audience may have surfaced MPT issues now being raised. For example, applying the basic tenets contained in the DCSPI "horseblanket," especially with reference to MANPRINT fundamentals such as an early target audience description, user needs analysis, MANPRINT concerns reflected in the statement of work to industry, and periodic independent MANPRINT assessments at key decision points. Application of the MANPRINT concept early in the HARDMAN III concept exploration and definition phase may have surfaced valid MPT concerns from a large segment of the U.S. Army analytical community--namely TRADOC. The Concept Based Requirements System (CBRS) is a structured process used by TRADOC that utilizes a set of procedures to identify and prioritize Army war fighting requirements for doctrine, training, leader development, organizations and materiel. The process used to produce the HARDMAN III software did not use the CBRS to determine what the ultimate user needs.

3.2 MANPOWER ISSUES

3.2.1 Major Differences Between HARDMAN III versus HARDMAN II. The HARDMAN III modules do not provide the same capability as the manual HCM or HARDMAN II in determining a materiel system's MPT requirements data. The MPT analyst is able to establish a BCS, using substep 6 of step 1 of the generic HCM, in order to project a proposed system's MPT requirements. An analyst, using HARDMAN III, could build a "scratch model" consisting of components already in the SPARC module. However, this procedure is complex and the reliability algorithm accuracy suspect since it is based on average daily usage vice a finite mission usage. HARDMAN III does not have the capability to create a BCS (using hardware components from other services or industry) which is considered to be a very crucial step in the HCM. For example, a recent task analysis performed on the Advanced Field Artillery System (AFAS) at Fort Sill, OK by a contractor used predecessor task data to predict the future AFAS tasks using the HARDMAN III software. The methodology used was similar to an Early Comparability Analysis. If the HARDMAN III had the capability to construct a BCS consisting of tasks reflecting new technology, the proposed AFAS task list may have been more realistic and useable for further MANPRINT analyses. Similarly, step 3 of the HCM Training Analysis allows the training analyst to establish BCS tasks (substep 4) and evaluate BCS tasks (substep 5). Most significant is T-CON's inability to perform the key training resource requirements analysis. The training analyst, via application of the HCM, is able to produce Quasi-Programs of Instruction (POIs), evaluate BCS courses of instruction, compute pipeline student loads, and determine the number of instructors and annual course costs using Army Training Requirements and Resources System (ATRRS) data.

3.2.2 Manpower Constraints versus Manpower Requirements. M-CON was not designed to generate a materiel system's theoretical manpower requirements. M-CON forces the analyst to design new Army systems for fielding within Army manpower ceilings and/or budgetary constraints. Conversely, TRADOC school combat developers determine unconstrained user manpower requirements to overcome the predecessor's deficiency or meet a new threat. Therein lies the dichotomy of using an MPT tool that views manpower constraints vice manpower requirements as the primary sensitivity criterion.

3.2.2.1 It is possible to eliminate M-CON constraints to determine unconstrained manpower requirements. Step 5 of the M-CON procedure contains the flow model projection enabling the MPT analyst to adjust the Army end strength. The documentation states that the impact of doing this will be to either increase or decrease the number of people required in a particular MOS. By raising the end strength, it is possible for the MPT analyst to eliminate the constraint factor.

3.2.2.2 Another possible way to eliminate constraints would be to adjust manpower constraints, using Step 6 of the M-CON procedure, to compensate for differences in the number of requirements as determined by Manpower Requirements Criteria (MARC) versus the actual number of positions authorized by the Army. Also, by adjusting for operating versus authorized manning, available manpower could be increased to meet conceptual requirements (see M-CON users guide and help screens). In summary, M-CON was not designed to generate manpower requirements. If the main purpose of M-CON is changed to generate requirements vice constraints, the documentation should reflect this.

3.3 PERSONNEL ISSUES

3.3.1 **Project A Database**. Project A, used to assess personnel performance in several of the HARDMAN III modules, may be obsolete since the ASVAB data reflects soldier capabilities in the 1980s. Using ten-year old personnel data to predict performances over the current time frame and into the future is misleading. The current generation of accessions consists of a much higher quality of soldier due to several social and economic factors in comparison to the early 1980s. Also, the assumption that performance characteristics from Project A degrade in a linear relationship may not be true, especially when multiple stressors are encountered by soldiers (e.g., adverse climate and NBC conditions).

3.3.2 **Personnel Selection Criteria**. It appears that there should be prerequisite criteria established prior to selecting U.S. Army and other DoD MPT analysts for attendance at the HARDMAN III training. Our review of all of the previous attendance rosters for the three day HARDMAN III training courses revealed that several attendees did not possess the academic or the occupational credentials to justify the HARDMAN III training. Several attendees were last minute substitutions that were merely "filling a seat" because the training course had been funded by their particular Army agency who had sponsored the training. Several of the HARDMAN III SMEs surveyed recommended that minimum prerequisites be established prior to attending the training. These prerequisites included: (1) Assignment to an MPT analytical position; (2) Knowledge of personal computers including Disc Operating Systems; and (3) Minimum of 1 year of MANPRINT experience.

3.4 TRAINING ISSUES

3.4.1 **Three-Day HARDMAN III Training Seminar**. The three-day training seminar merely provided the author with a familiarization and the basic rudiments of the HARDMAN III. It was conducted using a "guided tour" approach whereby each of the students received an initial briefing on each module and subsequently "walked through" the various steps that are necessary to perform a superficial analysis. The seminar was valuable in understanding the underpinnings of the modules and enabled the student to observe the reactions and perceptions of other similar students. The student also has the opportunity to ask questions in order to clarify any misunderstandings. Several of the SMEs surveyed (see **Appendix E**) were of the opinion that the training provided an overview of HARDMAN III but did not adequately prepare an MPT analyst to conduct a HARDMAN analysis. There was no intent to conduct the training in compliance with MIL-STD-1379D, the Army's SAT process or best commercial practices.

3.5 COEA INCOMPATIBILITIES WITH HARDMAN III

The COEA is considered to be the vehicle for centralized MPT analyses within TRADOC. MPT issues are an integral portion of the COEA, from both the operational effectiveness and cost perspectives of the analyses. As an integrating document, the COEA frequently addresses new concepts requiring databases from non-traditional sources (e.g., contractor or other DoD service maintenance data). In the case of the AGS, government furnished MPT data (limited by the SOW) from the AGS COEA study was used as a bench mark reference to verify the algorithms and outputs from the HARDMAN III software modules. The following problems were encountered with the AGS COEA data:

3.5.1 Outputs. AGS data was provided in a COEA format and we made comparisons between the outputs of the two methods (COEA and HARDMAN III) revealing disparities in the results. This is because SPARC, MAN-SEVAL, and PER-SEVAL utilize flow models that break RAM data into individual missions, while the AGS COEA uses annualized data (Note: the SPARC module does very limited RAM, mostly maintainability). Another drawback is the HARDMAN III software's cumbersomeness in generating multiple alternatives within a single workfile causing difficulty in computing MPT requirements for several alternatives required by COEA study plans. The MPT analyst is forced to download the HARDMAN III database and reconstruct a different database populated with equipment representing the COEA alternatives (currently not reflected in the HARDMAN III modules). It appears that the analyst could use the HARDMAN III software by computing each alternative as a separate analysis but this would be labor intensive vice using a "spreadsheet" analytical approach.

3.5.2 Replacement System. Creation of a replacement system not in the established library was a problem. The system being replaced by the AGS was the M551A1 Sheridan tank. Although sharing some similarities with the AGS, the M551A1 also included other replacement systems such as the M1 Abrams and M3 Bradley. Creation of a new replacement system was not as simple as it appeared. Some of the formulae become distorted by using replacement systems that are pieced together. For example, the M-CON replacement ratio algorithms employed data from the M1 Abrams tank instead of the M551A1 Sheridan (the library database contains the M1 as a replacement system type, and not the M551A1 Sheridan, which has far fewer fielded systems). The results of the formula used to determine new system densities grew distorted, making it appear that many more operators would be needed to field far more systems. It was possible to create correct new system densities by using the phasing in/out schedule utilizing the number of fielded systems broken down by the units that they are assigned to. In this case, they were units fielding M1 tanks. By assigning the number of M551A1 systems arbitrarily to M1 units, and doing the same for AGS systems to be fielded, it was possible to calculate true system densities. The difficulty is that one function had to be utilized incorrectly in order to compensate for a software deficiency. Also, the main driver behind reducing the AGS operator crew size from four to three was the introduction of an ammunition auto loader system, which is not a task included in the HARDMAN III database. Although allowances could be made to approximate this new task, wide variations in output could occur.

3.6 ASSESSMENT OF HARDMAN III SOFTWARE

3.6.1 Distribution of HARDMAN III Software. The HARDMAN III was initially distributed exclusively through several ARI field offices at Forts Rucker, Bliss, and Sill. These field offices have applied the software to several "notional" Army materiel systems (e.g., Patriot Navigation Emplacement System (PNAVES), AFAS, and Forward Area Refueling Point (FARP)). Several individuals involved in these tests were surveyed as SMEs (see **Appendix E**).

3.6.2 Lack of Technical Specifications. There were three different contractors - Dynamics Reseach Corporation (DRC), Micro Analysis & Design (MAD) and Applied Science Associates (ASA) who were involved in the design and development of the HARDMAN III software modules. The complexity of managing three different contractors may have led to the diverse software schemes used by each of the contractors such as use of the same key strokes, menus and procedures, etc. Detailed technical specifications could have demanded standardized features like the family of Macintosh software (e.g., commonalities with regard to menus, screen/window layout and routine functions).

3.6.3 Utility Assessment. The utility assessment was accomplished in two stages: module familiarization and evaluation. The assessment was performed on a combination of HARDMAN III software versions 1 and 2 using various releases (see **Table 3-1**). T-CON provided no version disclosure screen and therefore no version information was available on this module. Module familiarization consisted of learning the basics of HARDMAN III software operations. Installation time and tutorial time, as listed in **Table 4-1**, would be a subset of module familiarization, since the time listed to install the software was contingent on the machine speed and the time to run through the tutorial was contingent upon the amount of documentation provided. Additional time was required to gain an understanding of installation and tutorial procedures (not broken out in the chart but discussed in more detail in subsequent paragraphs). Installation procedures involved reviewing the documentation for installation steps and following screen directions. Tutorial steps were followed with information provided by the documentation augmented by AGS COEA data. An additional aspect of module familiarization was the time needed to perform a HARDMAN III analysis utilizing AGS data. Evaluation times are not given since they have no impact on workload for users in the field (who will be evaluating materiel systems and not software systems).

Table 3-1

HARDMAN III SOFTWARE VERSIONS

MODULE	FILE TYPE	VERSION	RELEASE DATE
MANSEVAL:	Program Version	2.6	7/02/92
	Library Database	2.3	3/26/92
	Work Database	2.2	8/26/91
	Library Database	1.8	3/26/92
	Work Database	1.5	8/14/91
	Help Database	2.1	8/08/91
M-CON:	M-CON	1.1	2/24/92
	System Working Files	1.0	8/26/91
	M-CON Library	1.13	2/24/92
	Flow Model Library	1.03	2/24/92
P-CON:	P-CON	1.10	2/24/92
	System Working Files	1.00	8/26/91
	P-CON Library	1.13	2/24/92
	Flow Model Library	1.03	2/24/92
SPARC:	SPARC Program Version	2.2	3/20/92
	SPARC PR1WRK Database Version	2.1	8/08/91
	SPARC PR1LIB Database Version	2.3	4/15/92
	SPARC PR1HLP Database Version	2.1	8/08/91
PERSEVAL:	PERSEVAL	1.04	2/20/92
	System Working Files	1.00	8/26/91
	PERSEVAL Library	1.1	12/18/91

3.6.4 Installation of modules

3.6.4.1 Versions. The HARDMAN III versions that we evaluated were obtained from ARL during the month of July 1992. The contractor provided a total of forty-six (46) 3 1/2" micro floppy disks (at no cost to the government) to ARL, who performed the diskcopy. After receiving the disks, they were loaded on an IBM compatible with an 80386 microprocessor and an 80 megabyte (MB) hard disk drive. Total bytes installed were 45,087,026 or 45 MB, of which 25,568,391 bytes were R:Base files (56.71% of the total) (see **Table 3-2**). The remaining 19,518,635 bytes were executable files and other file types that were not identified.

3.6.4.2 Workload. A total of 75 minutes (machine time) was required to install the software. An additional 15 minutes was required per module to read the documentation and initiate the installation process. The total installation time amounted to three hours. There were two distinct installation packages: one package shared by ASA and MAD for T-CON, SPARC and MAN-SEVAL, and one provided by DRC for M-CON, P-CON and PER-SEVAL installation. Since the installation packages developed for MAD and ASA products were alike in form and function, no distinction will be made between them. The MAD and ASA installation screens were graphical in nature and very user friendly. There was little narrative documentation provided and installation steps were provided on the screen. Prompts furnished guidance for the sequence of disk insertion. Anyone with minimal MS-DOS knowledge could perform this installation, e.g., an administrative technician, a junior staff analyst, etc. The installer program offers ample opportunity to escape out if the user makes a mistake and needs to cancel a command. This option is very useful during the initial installation. The DRC installation screen was not as graphical as the ones provided by MAD/ASA and lacked the user friendliness normally associated with a graphical display. DRC provided less narrative documentation compared to MAD/ASA. The user must be very careful operating the DRC installation screens since the disk prompts are slightly confusing and must be very careful and follow the directory prompt when it asks for a particular disk or to execute a particular command. Since the installer does not provide the user with an escape option during a function, the user must re-initiate the installation process if a significant mistake occurs. The installer of DRC programs must possess a working knowledge of MS-DOS and make error free procedural steps to ensure a successful installation. DRC does provide a de-installation package, in addition to the installation package, to correctly back-up the module. This is important since some HARDMAN III files cannot be backed-up onto a single disk. The flow model contained in M-CON and P-CON (over 3.5 MB) provides an example. When there are breaks in large files, the software must be told where the breaks are, or the file is not readable. The de-installer conducts this record keeping function. By making use of this back-up package, the need for another application to execute this function is eliminated. MAD/ASA does not list the availability of this function in its reference documentation.

TABLE 3-2
HARDMAN III
DATABASE REQUIREMENTS

	LIBRARY	WORK FILES	FLOW MODEL	HELP FILES	SYSTEM & VERSION CONTROL	TOTAL RBASE	TOTAL BYTES	% RBASE OF TOTAL BYTES
SPARC	2,155,009	25,529		3,678,467		5,859,005	9,124,540	64.21%
M-CON	158,692	24,002	3,847,649		215,034	4,245,377	6,684,222	63.51%
P-CON	822,504	10,086	3,847,649		204,319	4,884,558	8,725,792	55.98%
T-CON	2,323,077	373,032				2,696,109	3,792,970	71.08%
MAN-SEVAL	3,173,990	58,448		3,644,349		6,876,787	12,719,289	54.07%
PER-SEVAL	756,462	14,636			235,457	1,006,555	4,040,213	24.91%
	9,389,734	505,733	7,695,298	7,322,816	654,810	25,568,391	45,087,026	56.71%

3.6.4.3 Special Problems with T-CON. The installer modified the system configuration file--with unknown effects to the operating system. The installer changed the CONFIG.SYS files line to equal twenty (apparently T-CON will not run reliably with fewer than twenty files specified in the CONFIG.SYS file); also, the installer changed the AUTOEXEC.BAT file to open with the T-CON directory (not necessary since a simple C:CD\TCON will open the T-CON directory). The application requires very close to 640 K available random access memory (RAM) in order to operate, which is difficult to obtain on some machines given the amount of total RAM, the size and location of MS-DOS, and the existence of other memory-resident programs (e.g., Microsoft Windows or a local/wide area network). Most programs are designed to run at 512 K RAM, with the remaining space allocated for MS-DOS. By requiring over 600 K RAM, a hardware problem is created for many users since there may be insufficient space for memory-resident programs such as a mouse or antiviral software.

3.6.5 Tutorials. Each contractor provided a different tutorial with a different format. The amount of reference documentation varied, as well as the training style for each product. The tutorials ranged from practically non-existent (ASA) to highly graphical (DRC); reference documentation ranged from very little (DRC) to excessive narrative (MAD).

3.6.5.1 Each module utilized a distinctive presentation style, reflecting the different contractors involved, especially with respect to graphical display, format, and presentation of instruction. The training tutorial provided by MAD had a complex structure that would be difficult for the average analyst to quickly grasp. This presentation style was characterized by mixing reference documentation with a tutorial and not presenting the information in a simple and straightforward manner. Type-in values were only partially provided often forcing the user to furnish them and increasing the required execution time. The MAD product tutorial required two hours for SPARC and four hours for MAN-SEVAL, respectively. Do to the complex structure of the tutorial, the typical user would find it difficult to form a gestalt or overall understanding. Conversely, DRC provided a tutorial using a very graphical presentation style, but lacked a good written description of the procedures contained in the module; it was mostly a "structured walk-through." The tutorial consisted of a screen by screen presentation of the module's capabilities. "Type-in" values were provided to simplify the process, eliminating the need for the user to provide figures, and reducing the time requirement to perform the tutorial to about an hour per module. The lack of documentation places a burden on the user to learn many of the higher functions without the benefit of a written description. This approach, sometimes referred to as the "Video Game" approach (discovering higher functions by trial and error), is labor intensive and requires higher analytical skills, knowledge, and abilities. There is the added problem of retaining institutional knowledge with the video game approach. In the event the MPT analyst does not keep adequate historical records, the corporate knowledge may be lost when that individual rotates to another position. Regardless of the method used by the analyst to learn the software, good reference documentation should always be available.

3.6.5.2 ASA did not provide a true tutorial for T-CON. All that was included in the documentation was a section that described the steps in T-CON. No "type-in" values were provided, merely a discussion of the process.

3.7 HARDWARE AND SOFTWARE REQUIREMENTS

3.7.1 Hardware. The HARDMAN III modules were loaded on two IBM compatible PCs. The first PC used an 80286 processor with 640 K bytes RAM expanded to 1 MB, and incorporated an Enhanced Graphics Adapter (EGA). MS-DOS version 5.0 was loaded into high memory (640K to 1 MB). A total of 80 MBs was available on the hard disk. No math co-processor was present. The unit had two high density drives: one 3-1/2" and one 5-1/4" floppy disk drive. The second PC had a 80386 processor with 4 MB RAM, and operated at 33 mhz. The operating system was the MS-DOS Version 5.0 and used the Quarterdeck Extended Memory Manager (QEMM). It had an 80 MB hard disk drive with two high density floppy drives: one 3-1/2" and one 5-1/4." This PC utilized a Video Graphics Adapter (VGA) (see **Table 3-2** for database requirements). No math co-processor was present.

3.7.2 Inconsistencies. The HARDMAN III modules were designed to be consistent in architecture but many variations exist among the contractors' modules. The similarities include the universal use of the F1 key to access help files; each product screen provides the current path name for the file the user is accessing in order to establish an audit trail; also, all database files were written in R:Base. Other similarities are present, but the following include some of the dissimilarities. One of the inconsistencies involves print features. DRC programs included: a function command to print the current screen (as opposed to the print screen command which appears on the keyboard, limiting printing to what could be seen on the screen). Although this is a very useful feature, ASA and MAD did not include it in their programs, allowing only report and graphical printing. DRC provided a very simple screen to set print features (e.g., type of printer, printer port designation, graphic/text, etc.). Neither ASA nor MAD had this feature. DRC provided a de-installation application with their modules enhancing back-up procedures whereby large files can be divided among several disks. ASA and MAD provided a very graphical installation package that is user friendly, while DRC's displays are not as user friendly. Some inconsistencies exist among replacement systems contained in the database for the different contractors. For example, DRC lists the system name for the close combat light rifle as the M16A1; MAD lists the same system as the M16; ASA lists the M16A2. Also, DRC listed the M102 105 mm with the fire support towed howitzer system group. MAD did not include the M102. Therefore, if a user needs the M102 for a replacement system, the analyst can only use it with DRC products. ASA's product T-CON is very different than the other modules. It contains 34 mission areas compared to the 21 and 23 Battle Functional Mission Areas for DRC and MAD, respectively. T-CON requires a great deal more RAM to operate than the other modules and will not run reliably with less than 640 K bytes, creating an additional hardware problem since many PCs only have 640 K bytes of total RAM. Out of this 640 K, MS-DOS must be used as a memory-resident program in order for the machine to operate. Therefore, it is difficult for T-CON to run on a PC with less than 1 MB random access memory. Additionally, it takes an enormous amount of time to run a T-CON evaluation (e.g, on a PC with a 80386 processor it took 1.5 hours to run an analysis and over seven hours for a 80286 processor equipped PC). **Table 3-3** recaps the hardware inconsistencies among the six modules as a result of having three different contractors.

3.7.3 Linkages. Linkages are inconsistent prohibiting free transferability of work file data among modules. For example, SPARC is the first HARDMAN III product, but output from SPARC is not linkable with M-CON - the second product. P-CON (a DRC product) output is not linkable with PER-SEVAL (another DRC product), although both modules relate to personnel issues. Since many modules are not linkable, the user is forced to populate the workfiles of various modules with similar data, creating additional workload (see **Figure 3-1** for depiction of linkages, covering both import/export and backup). The possibility exists that an expert could manually change the header record for the import files and/or make other changes as necessary so that a module not previously configured to import/export that data file type could read it. Regardless, this topic is not covered in the reference documentation and the average user would lack the knowledge base to do that type of translation unaided.

3.7.4 Non-Standard Screen Features. The use of the escape key differs from module to module. In MAD products, it is possible to strike the escape key until the user has exited the module entirely. DRC products allow the user to escape back until reaching the main menu, and then no further. Item selection procedures differ from contractor to contractor. In SPARC, the user must employ a combination of arrow keys and the space bar. DRC products use only the space bar (since striking the space bar highlights a selection and drops to the next line down). This minor issue points out the larger issue of inconsistency and how it impacts workload. The user must remember all the small differences between the modules each time a particular module is accessed involving reviewing notes, documentation, etc. This increases the learning curve and causes additional physical and cognitive workload.

3.7.5 Disk Back-Ups Differ Among Contractors. When the user backs up data onto a disk using DRC generated software, the application automatically erases the destination disk. This precludes the user from placing multiple back-ups on the same disk. MAD's back-up utility, on the other hand, does not erase the disk, allowing for multiple back-ups on the same destination disk, which reduces overall cost. It

Table 3 - 3

Hardware Configuration Inconsistencies

- **Processor**

  80286

- **Random Access Memory**

  640K Bytes

- **Monitor**

  ASA: Monochrome or Color Display

  DRC: Not Specific

  MAD: Enhanced Graphics Display

- **Disk Drives**

  Floppy Diskette or Bernoulli Cartridge

- **Printer**

  ASA: Text Printer

  DRC: IBM Compatible Printer

  MAD: Dot Matrix, IBM graphics, 80 Characters per inch

- **DOS Requirements**

  ASA: MS DOS Version 3.2 or higher

  DRC: MS DOS Version 3.0 or higher

  MAD: MS DOS Version 3.2 or higher

HARDMAN III
MODULE LINKAGES

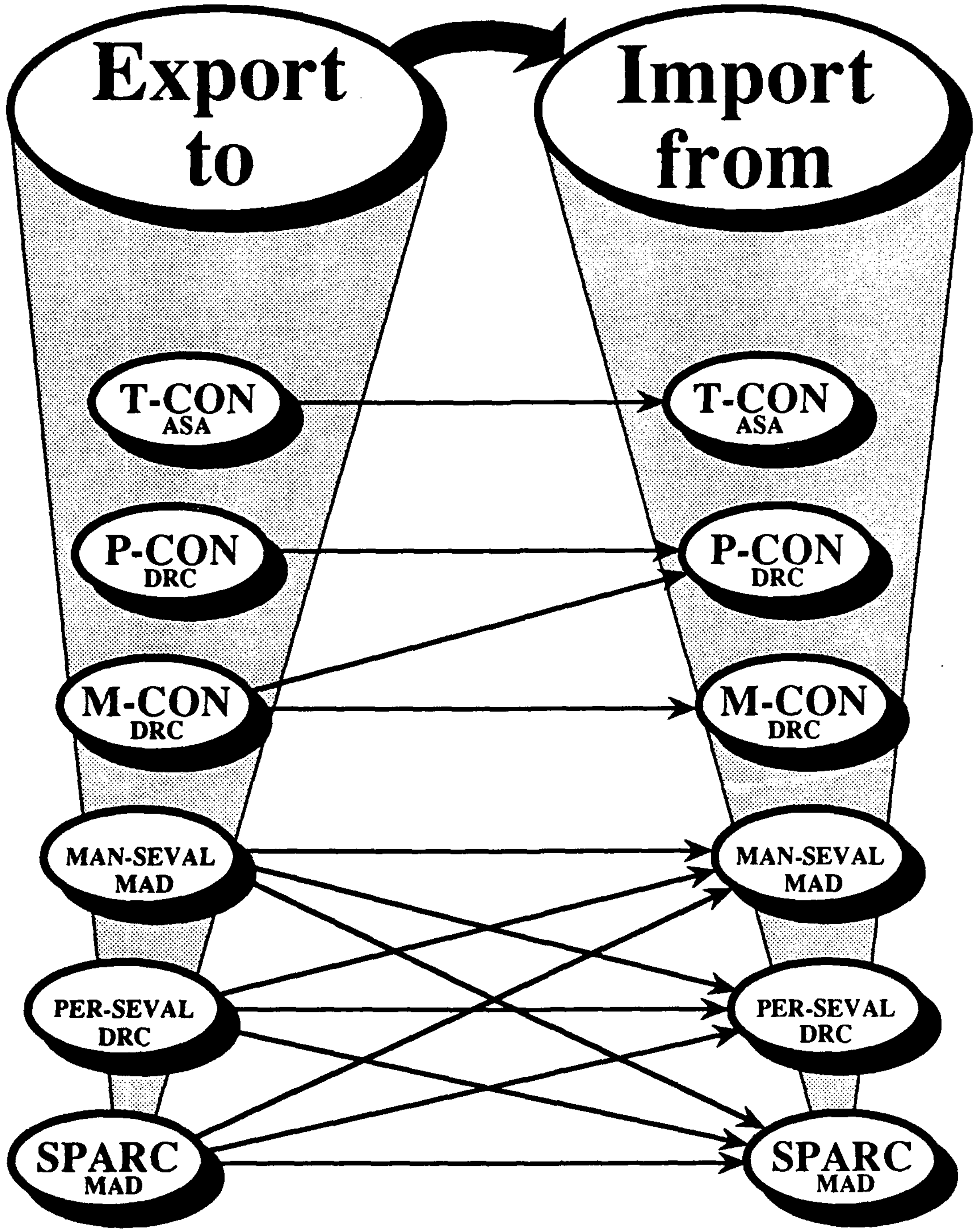


Figure 3-1

becomes necessary to re-read documentation each time the user accesses a particular module in order to become reacquainted with that particular module's functions and input procedures. The major similarity, among the modules, is that they are all menu driven and utilize a step-order approach to organize input. However, input patterns differ from contractor to contractor. This contributes to the major problem of the modules not being consistent with each other. This non-standardization requires additional time for the analyst to perform the steps of each module since the user must remember different application styles. It would have been much simpler if the modules were set up with more similarity thus improving user friendliness. At a minimum, even if the input pattern was not the best, the user would only have to learn it once, simplifying input operations.

3.8 DOCUMENTATION

All HARDMAN III modules came with documentation (all version 1.0), but the user manuals that were included often lacked utility or provided limited utility. This reduced the overall usefulness of the manual as a complete reference tool.

3.8.1 Incomplete Manuals. For example, only MAD's user manuals contained an index to facilitate reference searches. ASA included a list of acronyms and abbreviations but did not include a glossary of term definitions. DRC and MAD, on the other hand, did include a glossary of term definitions, but did not include a list of acronyms and abbreviations. DRC lists twelve mission areas in the software and in the documentation, although only six can be accessed in the module (which is not mentioned). Also, the system types that make up these mission areas are not listed at all. MAD does not list the mission areas or the system types in the documentation. ASA, on the other hand, lists all system types by mission area in the user manual. The user manual version is well behind the current software versions. MAN-SEVAL and SPARC are well into their second versions; M-CON, P-CON and PER-SEVAL have had many releases, which may include changes that are not reflected in the reference documentation. The reference manual documentation is laid out in a step approach, exactly as it is in the software. This is useful in order to illustrate the process involved in performing HARDMAN III analysis, but it is very limiting as well. Once an analyst has gone through the steps several times, he or she will become accustomed to the overall approach and will not need to repeat the tutorial in all future evaluations. This would imply that a more topical approach to reference source arrangement would be in order since the analyst would need to become reacquainted with specific functions and not the flow process in its entirety.

3.9 HELP SCREENS

Much of the documentation available to assist the user is contained in an assortment of help menus. These help menus are easily accessible, but often are limited to basic guidance (e.g., defining simple function commands). Additionally, the software does not document algorithms well, by way of screen alerts and messages. Often, the user does not know what goes on inside the computer when the screen says "wait". This can be troublesome when lengthy computations are being conducted.

3.9.1 Incomplete Information About Critical Items. For example, in the P-CON screen, "Assess MOS Availability and Performance," under edit task, the help screen only defines three taxons, although there are nine in total. Note: a taxon is a task classification category. For example, a visual task requires using the eyes to identify targets, a numerical task requires performing mathematical calculations, and a cognitive task requires processing information mentally and reaching a conclusion. It would be very helpful to the user to have all taxons defined since they must be independently attributed to specific tasks. Given the fact that the user must make a fairly subjective determination of taxon application, good definitions are crucial. Although help screens provide some reference utility, their use does not replace good user guide documentation.

3.10 DATABASE CONFIGURATION

Configuration control of various versions of HARDMAN III could present a problem given the number of separate modules with their different library databases, each containing varying degrees of conformance. This would constitute an additional workload for TRADOC Headquarters to maintain control of the various versions of the HARDMAN III data libraries.

3.10.1 Differing Versions. There are many different versions of the library database (see **Table 3-1**). The effective dates of the libraries range from PER-SEVAL (December 1991) to SPARC (April 1992). These databases contain different versions of weapon systems (as depicted earlier in reference to the M16 rifle) and not all modules have the same replacement system types (MAD does not include the M102, but DRC does). The output HARDMAN III produces is a result of information contained in the library database. As the user proceeds from one module to the next, database inconsistencies could distort overall output. This lack of uniformity is due to each module using the same replacement system types in different configurations.

3.10.2 Redundancies in the Database. The replacement system types are included (in one form or another) in all the modules, requiring a great deal of disk space to accommodate, and are listed in **Table 3-4**. Possible solutions to the problems of uniformity and redundancy are covered in subsequent sections. Also, a lot of data the user inputs into one module is similar to data that has been input into other modules, requiring additional workload.

3.10.3 Limitations in the Library. There are some limitations in the library database, since only six mission areas are included. DRC lists an additional six

Table 3-4

HARDMAN III Mission Areas

MISSION AREA	SYSTEM TYPE	SYSTEM NAME
Air Defense	HIMAD	Patriot
	Man-Portable Systems	Stinger
	Mobile Gun Systems	Vulcan
Aviation	Attack Helicopter	AH-64
	Cargo Helicopter	CD-47D
	Scout Helicopter	OH-58D
	Utility Helicopter	UH-60
Close Combat-Heavy	Cavalry Fighting Vehicle	M3
	Tanks	M1
Close Combat-Light	Anti-Tank Vehicle	ITV
	Anti-Tank Weapon	Dragon
	Grenade Launcher	M-203
	Infantry Fighting Vehicle	M2
	Machine Guns/Automatic	SAW
	Man-Portable Indirect	81mm Mortar
	Rifles	M-16
Combat Service Support	Heavy Cargo Trucks	HEMTT
	Light Cargo Trucks	HMMWV
Command and Control	No system type data	
Communications	No system type data	
Engineering and Mine Warfare	No system type data	
Fire Support	Medium range Missile	LANCE
	Rocket Systems	MLRS
	Self-Propelled Howitzer	M-109
	Towed Howitzer	M-198
Intelligence and Electronic Warfare	No system type data	
Nuclear, Biological and Chemical	No system type data	
Special Operations	No system type data	

mission areas that included no system type data (as listed in **Table 3-4**). These are Command and Control; Communications; Engineering and Mine Warfare; Intelligence and Electronic Warfare; Nuclear, Biological and Chemical; and Special Operations. If these mission areas and related system types were included in each library database, the total disk requirement would be substantially larger. An additional cost would be incurred by TRADOC to populate each database with this and other new data.

3.10.4 Configuration Control. Due to the lack of configuration/version control, there could be wide variations in the reliability of the individual HARDMAN III libraries, and it would require additional TRADOC manpower to manage them, in terms of verification and validation, since each library for each module would have to be independently reviewed.

3.10.5 Use of R:Base Software. HARDMAN III modules include R:Base data files comprising the Mission Area data library (see **Table 3-2** listing R:Base file types by functional category). HARDMAN III was designed so that users would not need the R:Base application to access data libraries. Although a licensed copy of the application is not distributed with the modules, copyright obligations still must be satisfied with respect to the R:Base generated data files. This is achieved by purchasing the application Run Time during product design, which acts as a licensing vehicle that can be used without distribution restrictions. Run Time is essentially an R:Base application that lacks the R:Base engine, and so data element editing functions are not possible. It consists of a command file and three (3) RBF files. But, it is necessary to have the full blown application present if the user or configuration manager needs to manipulate library data elements. For example, the application must be present to update existing data files or to create a new system database. Since R:Base is not in the public domain, an additional cost could be incurred for the purchase of licensed copies and to upgrade to higher versions. This presents a potential problem for the government in the event TRADOC distributed unlicensed copies of the copyrighted software such as R:Base or MicroSaint (see below).

3.10.6 Use of MicroSaint Software. MicroSaint is a PC-based discrete event simulation modeling tool used in several of the HARDMAN III modules (SPARC, MAN-SEVAL and PER-SEVAL) for replicating maintenance scenarios and predicting RAM results. The developers of microSaint (MAD) have given the government unlimited access to the use of the codes including approval to duplicate copies. Therefore, there is no problem of committing the government to a sole source use of this software. However, these privileges have not been extended to commercial firms.

3.10.7 Availability of Software From the Defense Technical Information Center (DTIC). There have been several advertisements in the MANPRINT bulletin stating that the HARDMAN III software was available from DTIC. An independent request for the modules was made which prompted a number of questions back from DTIC. The end result is that, as of the publishing of this report, it will take several more months to process and catalog the HARDMAN III software program for eventual distribution to DoD users.

3.11 AUDIT TRAIL

The author tended to become disoriented within a given HARDMAN III module. Although a pathname is provided at the top of each menu, it occasionally was unclear how the pathname related to the main menu.

3.11.1 Screens. During some steps in HARDMAN III modules, input screens are layered in order for the user to graphically determine where they are. This occurs frequently in the "Identify Systems to be Replaced" step. The application (DRC in particular) layers screens in a diagonal pattern that is easy for the user to follow. But, this does not occur in all cases. Sometimes in more detailed steps that require numerous sub-steps, it is easy for the user to become disoriented, in light of the assortment of escape commands and menu commands that are necessary to enter data or return to the main menu.

3.12 NEW MOSs

It is often necessary to create a new MOS for a new materiel system. HARDMAN III does not allow the MPT analyst to create new MOSs in the event that new and revolutionary technology requires increased personnel attributes or skill levels. This situation might be encountered when manual tasks are replaced by automated tasks. Because HARDMAN III utilizes MOSs that are included in a static database, it is difficult for the analyst to evaluate new materiel systems that might call for new MOSs, unless the analyst had access to the data libraries through R:Base. With the presence of the application R:Base, the analyst should have access and be able to make modifications to the library data files. This would require additional knowledge and reference documentation describing how this procedure is accomplished.

3.13 HARDMAN III Software Enhancements

Two of the contractors (DRC and MAD) that designed and developed five of the six HARDMAN III software modules (T-CON being the exception) have previously identified enhancements to improve HARDMAN III. These enhancements are contained in section 5 of the "Final Report for Concepts on MPT Estimation", dated December 1990 (see **Appendix B**).

3.14 COST AND MANPOWER REQUIREMENTS

The costs for operating and maintaining the HARDMAN III software for TRADOC and its schools, centers and field operating agencies are broken down as follows:

(a) Initial and recurring workload costs - estimated at approximately at least four weeks to load the initial software module and become proficient in its use (see **Table 3-5**).

(b) It appears that the computer hardware and software requirements needed to run HARDMAN III may have been underestimated by the developing contractors. **Table 3-6** lists the initial hardware requirements to properly operate the HARDMAN III modules.

(c) Initial and recurring training costs - approximately two weeks annually of training time is needed to attend the initial course and to undergo periodic refresher courses to overcome the high decay rates inherent in the use of the HARDMAN III software.

(d) Database operation and support (O&S) costs. HARDMAN III software configuration control would require one full time position and approximately $12,000 per quarter to maintain a centralized database (high fixed - low maintenance costs) if the HARDMAN III configuration were to be controlled and maintained by Headquarters TRADOC. The workload associated with the configuration control and standardization requirements as new versions are released appears to be labor intensive (see **Figure 3-2 and Table 3-5**).Note: the projected HARDMAN O&S costs were derived from the latest FOOTPRINT relational database costs. The configuration management costs of maintaining the HARDMAN III modules and databases could be expensive. Passing information via modem from a centralized HQ TRADOC location to individual schools could be time consuming (PC downtime during transmissions) and costly (purchase of modems and peripheral software and materials). Conversely, if each TRADOC school was assigned responsibility for its own PC database configuration control (low fixed - high maintenance costs) the costs would be significantly higher since each school would require one full time HARDMAN III analyst performing configuration control as an additional duty. In addition, each TRADOC MPT analyst will require additional 1 megabyte of disk storage capability to accommodate the HARDMAN III database requirements. This additional disk storage space requirement can be satisfied by acquisition of removable hard disk drives (e.g., Bernoulli box or Quantum Passport XL removable disk drive). Cost is $500.00 for a Passport XL installation kit (one per PC) and $800.00 per disk drive.

(e) An additional intangible requirement is the need to have TRADOC MPT analysts possess a high degree of prerequisite analytical skills, knowledge and abilities (see section 5) to become qualified in the HARDMAN III software.

(f) Classified hardware and software protection costs - PCs may need special protection by having a removable hard disk drive capability and classified safe in the

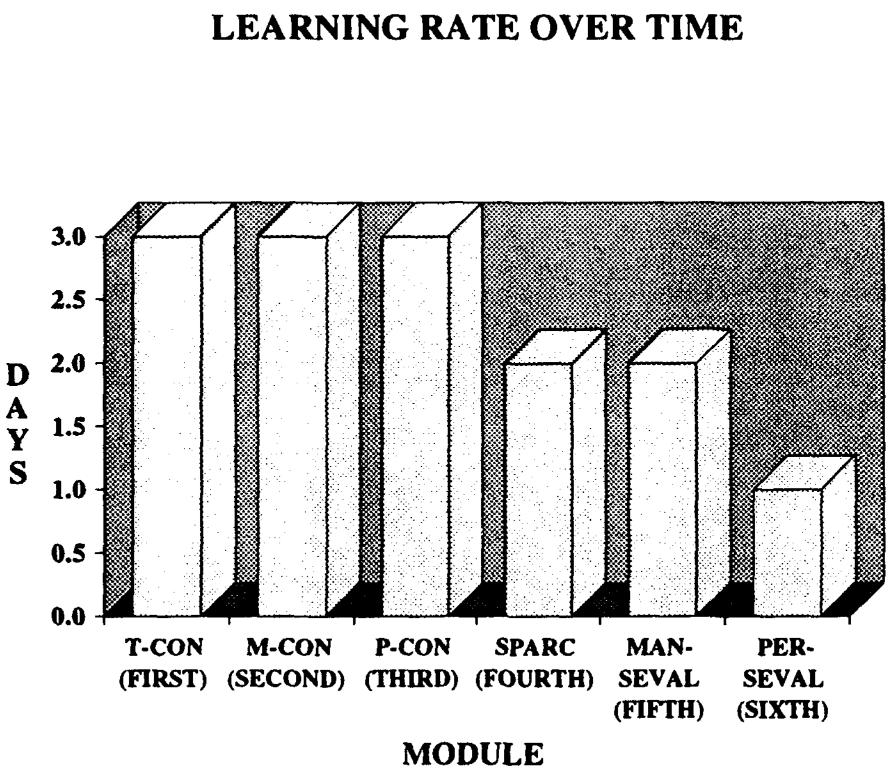


Figure 3-2

Table 3-5

START-UP WORKLOAD

	T-CON	M-CON	P-CON	SPARC	MAN-SEVAL	PER-SEVAL
Installation	10 Mins	15 Mins	10 Mins	20 Mins	15 Mins	5 Mins
Tutorial	1 Hr	1 Hr	1 Hr	2 Hrs	4 Hrs	1 Hr
Familiarization	3 Days	3 Days	3 Days	2 Days	2 Days	1 Day

TABLE 3-6

HARDMAN III
INITIAL HARDWARE REQUIREMENTS

	T-CON	M-CON	P-CON	SPARC	MAN-SEVAL	PER-SEVAL
No. of 3 1/2" Disks	5	6	6	10	15	4
Module Size	3,792,970	6,684,222	8,725,792	9,124,540	12,719,289	4,040,213
Disk Space Required*	4 MBs	8 MBs	8 MBs	20 MBs	20 MBs	5 MBs

*These estimates are based on version 1.0 documentation event it is necessary to use and analyze classified HARDMAN III data. In addition, a relational database management system software may be necessary to protect data during storage, manipulation and retrieval via a local area network.

(g) The configuration manager should be very careful making any changes to the structure of the data files, which could include changing data length or data type. A change made in one data file could affect other files, including executables, since the database is interrelated. These structure changes do not necessarily have to be made at the designer site, but could be made at Headquarters, TRADOC if the configuration manager has all the codes and applicable documentation available. Making changes only to the data elements should not be a problem, but care must be taken if any other files might be affected. It is also important that the configuration manager be a highly knowledgeable systems analyst in order to adequately perform these functions. This would increase the total cost since it would not be possible to assign these configuration management functions to an unqualified employee.

(h) The above costs could be exacerbated by the increasingly higher annual turnover and attrition in "green suit" military and Department of the Army civilian MPT analysts. This is a common phenomenon that is occurring more frequently in the TRADOC Headquarters, schools and agencies as the U.S. Army downsizes over the next 5 years.

The HARDMAN III O&S costs for Headquarters, TRADOC and its schools, centers and field operating agencies appear to be substantial (see **Table 3-7**). These costs assume that all HARDMAN III work will be performed in-house by DA analysts or military personnel. The configuration management assumes that all the codes and applicable documentation are available. Making changes only to the data elements should not be a problem, but care must be taken if any other files might be affected. It is also important that the configuration manager be a highly knowledgeable systems analyst in order to adequately perform these functions.

TABLE 3-7

HARDMAN III COST ANALYSIS

INITIAL START-UP COSTS

	Unit Cost	Number	Total Cost	Notes
Equipment Upgrades	$1,500.00	11	$16,500.00	Upgrade processor, RAM and hardrive
Installation of Software and Initial Training	$4,167.00	11	$45,837.00	1/12th manyear, based on a $50,000 per year salary
R:Base Application	$495.00	1	$495.00	One application for Configuration Manager
Training System Design	$40,000.00	1	$40,000.00	Computer Based Training development
TOTAL INITIAL COSTS			$102,832.00	

ANNUAL O&S COSTS

OPERATION

	Unit Cost	Number	Total Cost	
HARDMAN III Analysts	$50,000.00	10	$500,000.00	10 school analysts using an average yearly salary of $50,000

SUPPORT

	Unit Cost	Number	Total Cost	
Configuration Management	$50,000.00	1	$50,000.00	1 Configuration Manager at HQ, TRADOC
Training of Replacement MPT analyst	$4,167.00	3	$12,501.00	Average annual attrition rate of 3 per year
Computer Supplies	$20,000.00	11	$220,000.00	Peripherals
TOTAL COST			$282,501.00	
TOTAL ANNUAL O&S COSTS			$782,501.00	

NOTES:
1) Assumes all HARDMAN III work is performed in-house.
2) Assumes there will be one (1) Configuration Manager at HQ, TRADOC and one user manyear at each of the major TRADOC schools (estimated 10 sites).

SECTION 4.0
FINDINGS AND CONCLUSIONS

4.0 FINDINGS AND CONCLUSIONS

The findings and conclusions discussed below are based on the HARDMAN III surveys, discussions with MPT SMEs from a wide section of the Army, attendance at the three-day HARDMAN III training seminar, comparison of HARDMAN III with AGS COEA MPT methodology, and evaluation of the HARDMAN III software modules.

4.1 FINDINGS

4.1.1 HARDMAN III is a Misnomer. Several of the six modules do not enable an MPT analyst to calculate a materiel system's manpower and training resource requirements data that previously could be determined using the HCM. The HCM allows an MPT analyst to employ several methods ranging from the manual "stubby pencil" method to the Digital Equipment Corporation (DEC)/VAX mainframe based Man-Integrated System Technology (MIST) (HARDMAN II) software, and the recent personal computer software versions (HARDMAN II.2 and II.3) to produce a myriad of MPT reports. These typical HARDMAN products are then used as source documents used to feed and support key milestone decision review documents such as the Manpower Estimate Report (MER), the COEA, the System MANPRINT Management Plan (SMMP), the Baseline Cost Estimate (BCE), and Cost Analysis Requirements Document (CARD). Note: Most HARDMAN III surveyees were not aware that HARDMAN III, as a performance measurement tool, is considerably different from the generic HARDMAN methodology. Notwithstanding the apparent confusion over HARDMAN III, a more crucial issue is whether the HARDMAN III modules can be used to produce MPT requirements after the enhancements are made.

4.1.2 MANPRINT Concept Not Applied. MANPRINT considers soldier performance and reliability early in the materiel development and acquisition process. MANPRINT ensures that future materiel acquisitions will incorporate design features that allow a greater cross section of our projected soldier target audience force to successfully operate and maintain the proposed equipment. In the case of fielding the HARDMAN III software, the MANPRINT concept should have been employed by ARL by adequately researching the intended target audience (e.g., TRADOC analysts) and performing a needs analysis of what the ultimate user wanted and needed to better perform a MPT analyses. A suggested approach would have been to have a series of in-process reviews with a technical advisory group consisting of a cross section of MPT analysts to get early SME involvement. This approach may have prevented most of the user friendliness problems inherent in the HARDMAN III software. The ultimate question for the HARDMAN III user is - can this TRADOC analyst, with this HARDMAN III training, perform the desired MPT analytical tasks, to the TRADOC school standards, under the current TRADOC DCD and DOTD school conditions? The answer appears to be negative because the HARDMAN III software did not undergo the recommended robust MANPRINT process that could have prevented most of the problems experienced by several TRADOC users and expressed via the HARDMAN III surveys. The HARDMAN III software should have been "MANPRINTED" using the appropriate military standards and Army guides to ensure that prospective Army analysts could perform an accurate MPT analysis in the most cost effective manner.

4.1.3 Project A Database may be Outdated. The performance data extracted from Project A forms the basis for the HARDMAN III performance data since it was considered the best available data at the time. HARDMAN III uses the ASVAB data to predict task performance of the available soldier population, gauge the effects of operating and maintaining materiel systems varying quality of soldiers, and soldier aptitude requirements for existing, developing, and non-development item (NDI) systems. A major difficulty with using the Project A database is the fact that recent accessions of higher quality soldiers over the past five years perhaps have rendered the Project A database out of date and could be misleading since the original performance data represents a higher percentage of non-high school graduates (Category III and IV individuals) in the 21 MOSs tested than are currently being recruited. This skewed data might be acceptable, but current validity could be in question since it would be difficult to remove the bias. Also, there is a validity question concerning the use of SQT scores as an indicator of performance potential for Project A. Project A may also be erroneous from the standpoint that personnel performance characteristics may not follow linear patterns, especially when multiple stressors are encountered. Finally, there is the questionable validity of extrapolating performance data from 21 core MOSs to more than 250 additional MOSs. Use of such specious data to predict performance capabilities and evaluate stressors, especially when projecting into the late 1990s and beyond, could provide misleading or erroneous data to U.S. Army analysts.

4.1.4 Evaluation of Training. Although there was no intent to design and develop the HARDMAN III training seminar in accordance with MIL-STD-1379D (the guiding directive for military training programs), the HARDMAN training appears to be inadequate to properly train and qualify a typical Army MPT analyst as a HARDMAN III analyst. An improved tutorial inherent in the software modules would be a significant improvement and should eventually replace the three-day seminar. The improved HARDMAN III tutorial, supplemented by a demonstration program to "walk the analyst" through a typical HARDMAN III problem, would be a more cost effective way of training new HARDMAN III analysts and overcome the inadequacies of the training seminar. Also, any formal training course should only be developed after the target audience has been identified and defined.

4.1.5 Evaluation of HARDMAN III Software. The following findings were determined as part of the HARDMAN III utility Assessment.

4.1.5.1 An evaluation of user interface with respect to the module reference documentation and application screens was conducted. During the evaluation, many inconsistencies were uncovered revealing a lack of compliance with DOD-STD-2167A, "Defense System Software Development."

(a) There are non-standard tutorial documentation among modules. The tutorial documentation for each module used different styles, reflecting the different contractors involved, especially with respect to the graphical displays, format, and presentation of instruction. The products provided by MAD have a complex structure that is difficult to understand for the average analyst. By the same token, DRC provided a very graphical tutorial presentation style, but lacked a good written description of the sequence of events. Given the complexities inherent in the software modules, some type of training should be included with each module.

(b) There is limited or incomplete HARDMAN III documentation. For example, the "Structured Walk-Through" tutorial provided in the DRC products lacked sufficient information for the user to grasp in a timely fashion and apply to different situations. This contributes to a lack of understanding of where one is in the process since there is no path or logic trail to follow.

(c) It appears that linking all modules was a fundamental error. An erroneous assumption was made that all users would be using all modules. This is not the case, as borne out by the HARDMAN III surveys. Most responders indicated that one or possibly two modules would be useful to their MPT analytical needs. Again a thorough needs analysis would have identified the target audience and the necessary analytical tools necessary for TRADOC MPT analysts to perform their analyses.

(d) There was an absence of technical specifications from the government to the contractors requiring the HARDMAN III modules to be standardized. These specifications could have demanded that the same scheme be employed, such as the same key strokes, menus, procedures, etc., with regard to menus, screen/window layout, and routine functions, etc.

4.1.5.2 The AGS COEA study was provided by the government as a reference for the analysis using HARDMAN III. The AGS information was provided in a COEA format that makes translation into the HARDMAN III format difficult. The main driver behind reducing the AGS operator crew size from four to three was the advent of an autoloader, which is not a task included in the HARDMAN III database. Although allowances were made to approximate this and several other new tasks, wide variations in output occurred and were observed.

4.1.5.3 Configuration control inherent in managing and monitoring various versions of HARDMAN III could present a problem given the number of separate modules with their different library databases each containing varying degrees of conformance. This would constitute an additional workload for Headquarters TRADOC to maintain control and standardization of the various versions of the HARDMAN software modules especially as additional capabilities like Force Analysis Aid (FORCE), Human Operator Simulator (HOS), and the Manpower Capability Aid (MANCAP) modules are added at a later date.

4.1.6 **Positive Aspects of HARDMAN III.** There is some utility in the selected use of the HARDMAN III modules and these are as follows:

4.1.6.1 The SPARC database provides a compendium of databases for 21 mission areas that provides Army MPT analysts the ability to research a database from "scratch." Updating the SPARC database with the latest RAM data then provides the analyst with a substantial time savings in constructing the first generation of mission area data.

4.1.6.2 The MAN-SEVAL and PER-SEVAL modules are excellent tools that can be used to evaluate the relative merits of materiel systems. People limiting factors (e.g., taxons such as motor functions, continuous versus discrete tasks and climate stressors (e.g., cold, heat and noise) and the impact of mission oriented protective posture (MOPP) gear) can be evaluated by materiel developers.

4.1.6.3 Several of the HARDMAN III constraint modules (especially M-CON and P-CON) appear to have direct applicability to U.S. Army headquarters, field operating agencies and support contractors involved in performing trade-off analyses pertaining to materiel acquisition activities.

4.1.6.4 The R:Base database provides an integrated customized capability that could be modified with the most up-to-date RAM data and fit the needs of Army MPT analysts who evaluate personnel attributes of new materiel systems.

4.1.6.5 HARDMAN III is an excellent tool for planners to run mission simulations involving critical path analysis to vary different tasks to complete a mission.

4.1.7 **HARDMAN III Analytical Limitations.** The most significant limitation in the HARDMAN III is the difficulty in constructing a BCS via a "cut and paste" method using the HARDMAN III modules and have the data flow through the entire module. The MPT analyst should have the capability to create a notional system consisting of various Army, DOD, foreign or industry components in order to compute MPT requirements for various alternatives and then do comparisons. HARDMAN III does not have the capability to build a BCS in the same manner as HARDMAN II. Another drawback of HARDMAN III is its inability to accommodate a new MOS such as a combined operator-maintainer. With the high probability that technological changes will occur in future materiel systems, it is essential that HARDMAN III address the creation of new MOSs.

4.1.8 Training Prerequisites. Based on the surveys, interviews with HARDMAN III SMEs and attendance at the three day training seminar, there should be minimum educational prerequisites established for prospective Army analysts prior to investing valuable training time and human resources in the HARDMAN III training programs.

4.1.8.1 The present three day training seminar is insufficient by itself to qualify the average U.S. Army MPT analyst as a confident and proficient HARDMAN III analyst given the limited amount of documentation and tutorial training available.

4.1.8.2 There is insufficient documentation for a person unskilled in the application of MPT methodologies to conduct an MPT analysis on a U.S. Army materiel system using the HARDMAN III modules even if the modules were directed toward typical analysis questions.

4.2 CONCLUSIONS

Based on the technical approach used (see section 2), the following conclusions can be made:

4.2.1 HARDMAN III Modules not Designed for the TRADOC MPT Analyst. TRADOC DCD analysts are more concerned with unconstrained operator and maintainer manpower requirements instead of artificially constrained or limited percentages of available manpower inherent in the M-CON module. The interests and needs of higher headquarters agencies (e.g., HQ DCSOPS, SARDA) are different from TRADOC schools (DCD, DOTD). For example the former are more concerned with funding constraints for budgetary purposes while the latter organization determines unrestricted MPT requirements. Conversely, TRADOC DOTD analysts are interested in an emerging materiel system's impacts on POIs, instructor manpower requirements, student man-days, and course costs - none of which are provided by T-CON.

4.2.2 Required HARDMAN III Software Enhancements. The enhancements to the HARDMAN III software modules (described in section 5 of the "Final Report for Concepts on MPT Estimation") are necessary to rectify the flaws that currently exist. This conclusion is based on the premise that other agencies other than TRADOC may be able to use and/or afford HARDMAN III.

4.2.3 Cost/Benefit Analysis for TRADOC. The HARDMAN III cost analysis is explained in detail in section 3. The cost analysis considered the following factors: (1) the cost to input new or updated information; (2) the workload associated with verification, validation and manipulation of data based on a centralized or decentralized configuration; and (3) initial start-up and steady state condition MPT costs. The tangible and intangible costs more than outweigh the advertised benefits of HARDMAN III and provides ample justification for TRADOC to decline sponsorship of HARDMAN III. The bottom line issue for TRADOC is that it can ill afford the initial and recurring O&S costs associated with HARDMAN III when measured against the anticipated benefits as an MPT analytical tool.

SECTION 5.0

RECOMMENDATIONS

5.1 RECOMMENDATIONS

The recommendations suggested in paragraphs 5.1.1, 5.1.4 and 5.1.5 below are not original since they have been previously cited by the prime contractors who developed the HARDMAN III software modules. Several of these recommendations were reconfirmed on critiques provided by students who have attended the three day training seminars. Recommendations cited in paragraphs 5.1.2, 5.1.3 and 5.1.6 are based solely on this independent HARDMAN III utility assessment. Several recommendations are also premised on the notion that agencies other than TRADOC may be able to use and/or afford HARDMAN III.

5.1.1 HARDMAN III Enhancements. Proceed with the recommended enhancements for HARDMAN III modules as described is Section 5 of "Final Report for Concepts on MPT Estimation (Development of MANPRINT Methods)," prepared for the U.S. Army Research Institute, dated December 1990. Especially important are improvements and periodic updates to the SPARC database. Suggest low cost fixes to salvage the best modules (SPARC, MAN-SEVAL and PER-SEVAL). T-CON should be scrapped for the following reasons: (1) T-CON does not provide useful information to the trainer in its current format; (2) T-CON only contains information on existing POIs; (3) T-CON fails to provide the necessary ingredients for the System Training Plan such as data on training assumptions, constraints and issues. Project A performance data needs to be updated to reflect the current generation of high quality soldier aptitudes and performance capabilities.

5.1.2 HARDMAN III Training. It appears cost effective to develop a computer based training (CBT) tutorial to train prospective analysts in the HARDMAN III methodology. A CBT tutorial supplemented by a demonstration of a typical HARDMAN III analysis could replace the current three-day seminar and provide a more effective training program. A CBT program would probably require an investment of $35,000 to $45,000 to produce. However, cost savings accruing from elimination of the three-day seminar held twice a year could pay for the CBT within two to three years (assumes $10,000 per training seminar for travel, per diem, and salaries conducted by two out-of-town contractors, two ARL monitors, and 20 government students [half from out-of-town]). Use of CBT would also facilitate version updates and make configuration control much easier. Another possible frugal alternative is to produce a video cassette recording (VCR) to provide basic familiarization training to those individuals requesting an overview of the HARDMAN III modules who will not be performing actual MPT analyses on materiel systems (e.g., OSD officials, other services, contractors, etc.).

5.1.3 **Develop Personnel Selection Criteria.** In order to get the best possible return on the investment in training of new HARDMAN III analysts, there needs to be personnel selection criteria for both military and Department of the Army civilian analysts for selection as HARDMAN III analysts. Criteria should be in the form of prerequisite skills, knowledge and abilities (SKAs). Note: These criteria should be used by the Army as a guide only and are not intended to change civilian personnel regulations. For example, a typical HARDMAN III analyst might possess the following qualifications:

5.1.3.1 Bachelor's degree in a technical, training, or educational field of study. Knowledge of operations research/systems analysis (ORSA), or statistical modeling is desired.

5.1.3.2 Minimum of two years computer literacy in the Micro Soft Disk Operating System (MS-DOS).

5.1.3.3 At least three years experience associated with a U.S. Army mission area or materiel acquisition process to which the analyst will subsequently be assigned.

5.1.3.4 Minimum of two years experience in the application of MPT methodologies and techniques like HARDMAN, Training Impact Analysis (TIA), and other MANPRINT analyses.

5.1.4 **Consolidate Disparate Databases.** Consolidating the various databases into a single library and possibly consolidating several of the modules together would rectify many of the inconsistencies inherent in HARDMAN III. The following benefits could be realized:

5.1.4.1 A consolidated database would be easier to control and verify. Also, it would be much easier to keep one database updated than the current six.

5.1.4.2 Along with the library database, all work files should be consolidated as well to eliminate input redundancies.

5.1.4.3 This would reduce user workload and data file inconsistencies among modules as well.

5.1.4.4 By consolidating several of the modules, workload could be reduced as well as disk space since many of the inherent redundancies would be eliminated.

5.1.5 **Improve Module Linkages.** Recommend improving the linkages among modules to facilitate the transfer of data since data from one module is similar to data required by another module. Currently, transfer of data is not possible in all cases, e.g., data in P-CON cannot be transferred to PER-SEVAL, although both deal with personnel issues (Note: this recommendation is based on the premise that there is some HARDMAN III utility to Army agencies outside of TRADOC).

5.1.6 TRADOC Sponsorship. Even with the enhancements to salvage the HARDMAN III software modules, we do not recommend the sponsorship of the HARDMAN III software by Headquarters TRADOC for the reasons cited in Section 4. TRADOC school Combat Development Directorates analysts require support in developing, defining and evaluating a real or conceptual materiel system for input into the Operational Requirements Document (ORD). However, the HARDMAN III modules were not designed with DCD user in mind for the reasons previously cited in section 4. In the event TRADOC schools require additional analytical support, recommend contractor augmentation. For example, the U.S. Army Air Defense Artillery School and Center (USAADASCH) at Fort Bliss and the U.S. Army Intelligence Center and School (USAICS) at Fort Huachuca are programmed to receive a number of additional materiel systems between now and the year 2000. It may be prudent for these schools to contract out for the application of HARDMAN III since the O&S costs associated with HARDMAN III appear to outweigh the potential benefits derived from determining new materiel systems MPT requirements, concerns and issues assuming ultimate verification and validation.

In summary, ARL's Human Research and Engineering Directorate has met its primary organizational goal and charter and has produced an MPT analytical tool for possible use by Army organizations, DoD agencies and prime contractors. However, the utility of the HARDMAN III software is suspect until appropriate software modifications are completed (including verification and validation), documentation is updated to reflect current software configurations, and an adequate training package is developed to provide potential users with proper instruction regarding the applications, functions, and operations of the HARDMAN III software.

APPENDIX A

ACRONYMS

AFAS	Advanced Field Artillery System
AGS	Armored Gun System
AIR	American Institutes for Research
AMC	Army Materiel Command
ARI	Army Research Institute
ARL	Army Research Laboratory
ASA	Applied Science Associates, Inc.
ASARC	The Army Systems Acquisition Review Council
ASVAB	Armed Services Vocational Aptitude Battery
ATRRS	Army Training Requirements and Resources System
BCE	Baseline Cost Estimate
BCS	Baseline Comparison System
CARD	Cost Analysis Requirements Document
CBT	Computer Based Training
CBRS	Concept Based Requirements System
COEA	Cost and Operational Effectiveness Analyses
DCD	Directorate of Combat Development
DCSPI	Deputy Chief of Staff for Personnel Integration
DEC	Digital Equipment Corporation
DOD	Department of Defense
DOTD	Directorate of Training Development
DRC	Dynamics Research Corporation
DTIC	Defense Technical Information Center
ECA	Early Comparative Analysis
EGA	Enhanced Graphics Adapter
FARP	Forward Area Refueling Point
FORCE	Force Analysis Aid
FY	Fiscal Year
HARDMAN	Hardware versus Manpower
HCM	HARDMAN Comparative Methodology
HOS	Human Operator Simulator

HEL	Human Engineering Laboratory
HumRRO	Human Resources Research Organization
MAC	Macintosh Computer
MAD	Micro Analysis and Design, Inc.
MAISRC	Major Automated Information Systems Review Council
MANCAP	Manpower Capability Aid
MANPRINT	Manpower and Personnel Integration
MAN-SEVAL	Manpower-Based System Evaluation Aid
MARC	Manpower Requirements Criteria
M-CON	Manpower Constraints Aid
MER	Manpower Estimate Report
MIL-STD	Military Standard
MIST	Man Integrated Systems Technology
MMI	Man-Machine Interface
MOPP	Mission Oriented Protective Posture
MOS	Military Occupational Specialty
MPT	Manpower, Personnel and Training
MS-DOS	Micro Soft Disk Operating System
NAVES	Navigation Emplacement System
NDI	Nondevelopment item
O&S	Operation and Support
ORD	Operational Requirements Document
ORSA	Operations Research/Systems Analysis
OSD	Office of the Secretary of Defense
OTEA	Operational Test and Evaluation Agency
PC	Personal Computer
P-CON	Personnel Constraints Aid
PDRI	Personnel Decisions Research Institute
PEO	Program Executive Officer
PERSCOM	U.S. Total Army Personnel Command
PER-SEVAL	Personnel-Based System Evaluation Aid
PM	Program Manager
PNAVES	Patriot Navigation Emplacement System
POIs	Programs of Instruction
QEMM	Quarterdeck Extended Memory Manager

RAM . . . . Random Access Memory
RAM . . . . Reliability, Availability and Maintainability
RBF . . . . R:Base File

SARDA . . . . Secretary of the Army for Research, Development and Acquisition
SAT . . . . Systems Approach to Training
SKA . . . . Skills, Knowledge, and Ability
SMEs . . . . Subject Matter Experts
SMMP . . . . System MANPRINT Management Plan
SPARC . . . . System Performance and RAM Criterion Estimation Aid
SQT . . . . Skills and Qualification Tests

T-CON . . . . Training Constraints Estimation Aid
TIA . . . . Training Impact Analysis
TRAC . . . . TRADOC Analysis Command
TRADOC . . . . . . Training and Doctrine Command

USAADASCH . . . U.S. Army Air Defense Artillery School and Center
USAICS . . . . . . U.S. Army Intelligence Center and School
USTAPC . . . . . . U.S. Total Army Personnel Center

VCR . . . . *Video Cassette* Recording
VGA . . . . Video Graphics Adapter

APPENDIX B

LIST OF DOCUMENTS

The following list of referenced documents, reports, software and other pertinent information has been reviewed as part of the HARDMAN III utility assessment including a Manpower, Personnel and Training (MPT) analysis:

- Final Report (E-17611U) for Concepts on MPT Estimation (Development of MANPRINT Methods) produced by Dynamic Research Corporation, Inc. and Micro Analysis & Design, December 1990 for the U.S. Army Research Institute (ARI)

- Armored Gun System (AGS) MPT data on computer disks

- Software and User Guides for all six HARDMAN modules:

  -- System Performance and RAM Criterion Aid (SPARC)

  -- Manpower Constraints Aid (M-CON)

  -- Personnel Constraints Aid (P-CON)

  -- Training Constraints Aid (T-CON)

  -- Manpower-based System Evaluation Aid (MAN-SEVAL)

  -- Personnel-based System Evaluation Aid (PER-SEVAL)

- HARDMAN III Training Course (November 7-9, 1990 and 29 June-1 July 1992) handouts developed by Micro Analysis & Design Inc. and Dynamics Research Corp

- Walk-Through of HARDMAN III briefing slides given to U.S. Army TRADOC, 22-23 April 1992, by Drs. Laurel Allender and Engin Crosby of the U.S. Army Research Laboratory

- AGS Cost and Operational Effectiveness Analysis (COEA) Manpower and Personnel Analysis Plan, 22 March 1991

- HARDMAN III briefing given to Col Macey HQ TRADOC by LTC Correia on 13 February 1992

- HARDMAN II Comparability Methodology, Seven Volume Report, May 1990, developed for the Manned Systems Group (SRL), U.S. Army Research Institute

- HARDMAN, Five Volume Report, April 1985, prepared for the Technical Information Division, U.S. Army Research Institute

- Man Integrated Systems Technology (MIST) Users Guide produced by Dynamics Research Corp., 4 September 1985, for the U.S. Army Research Institute

- DoD Directive 7920.1, "Life Cycle Management of Automated Information Systems," June 20, 1988

- DoD-STD-2167A, "Defense System Software Development"

- DoD-STD-2168, "Defense System Software Quality Program"

- Development and Field Test of the Trial Battery for Project A, May 1987, produced by the U.S. Army Research Institute

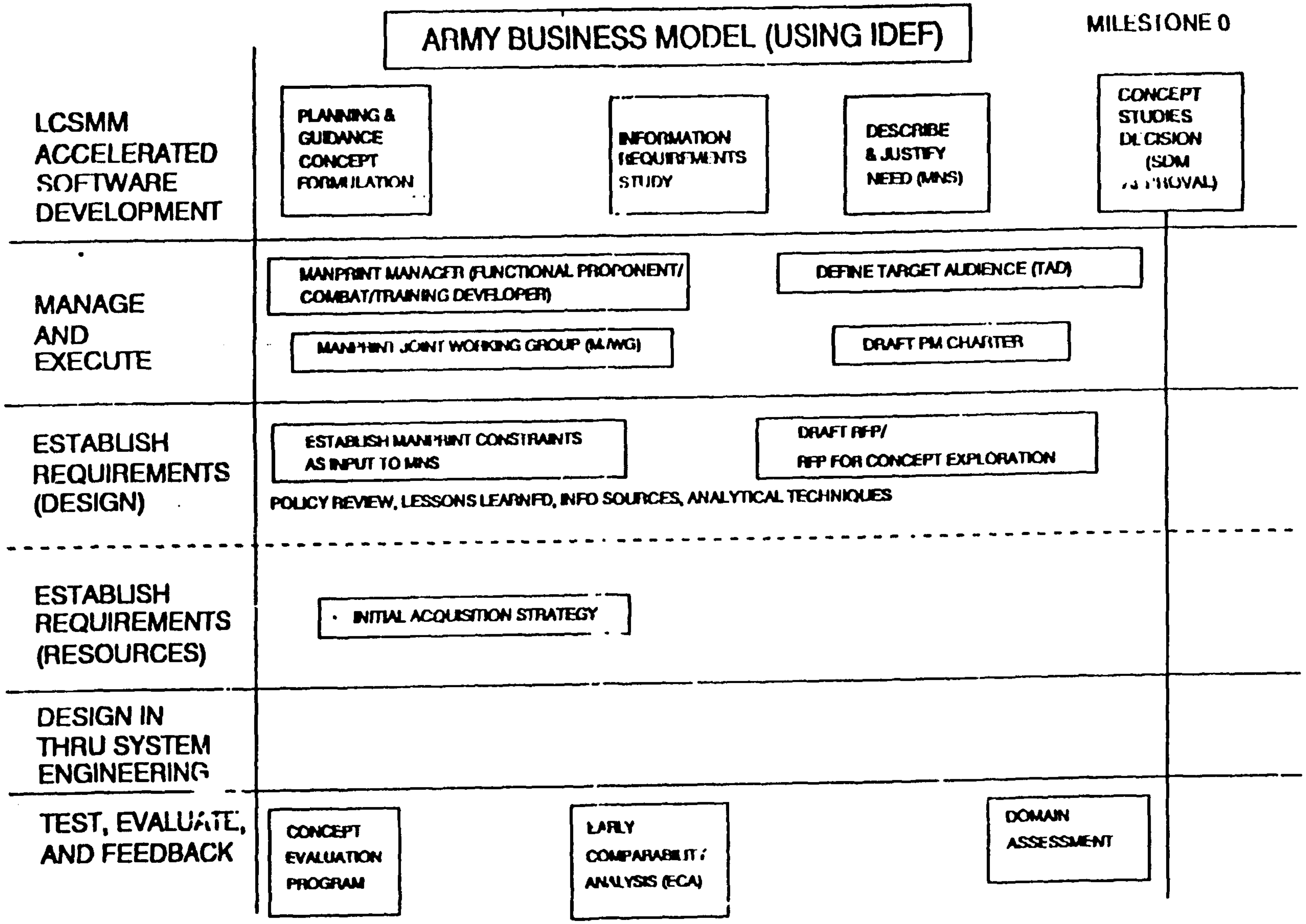
- Draft Advanced Field Artillery System (AFAS) Task List, July 31 1992, produced for the U.S. Army Research Institute, Fort Sill Field Unit by CAE-Link Corporation of Falls Church, VA using HARDMAN III

APPENDIX C

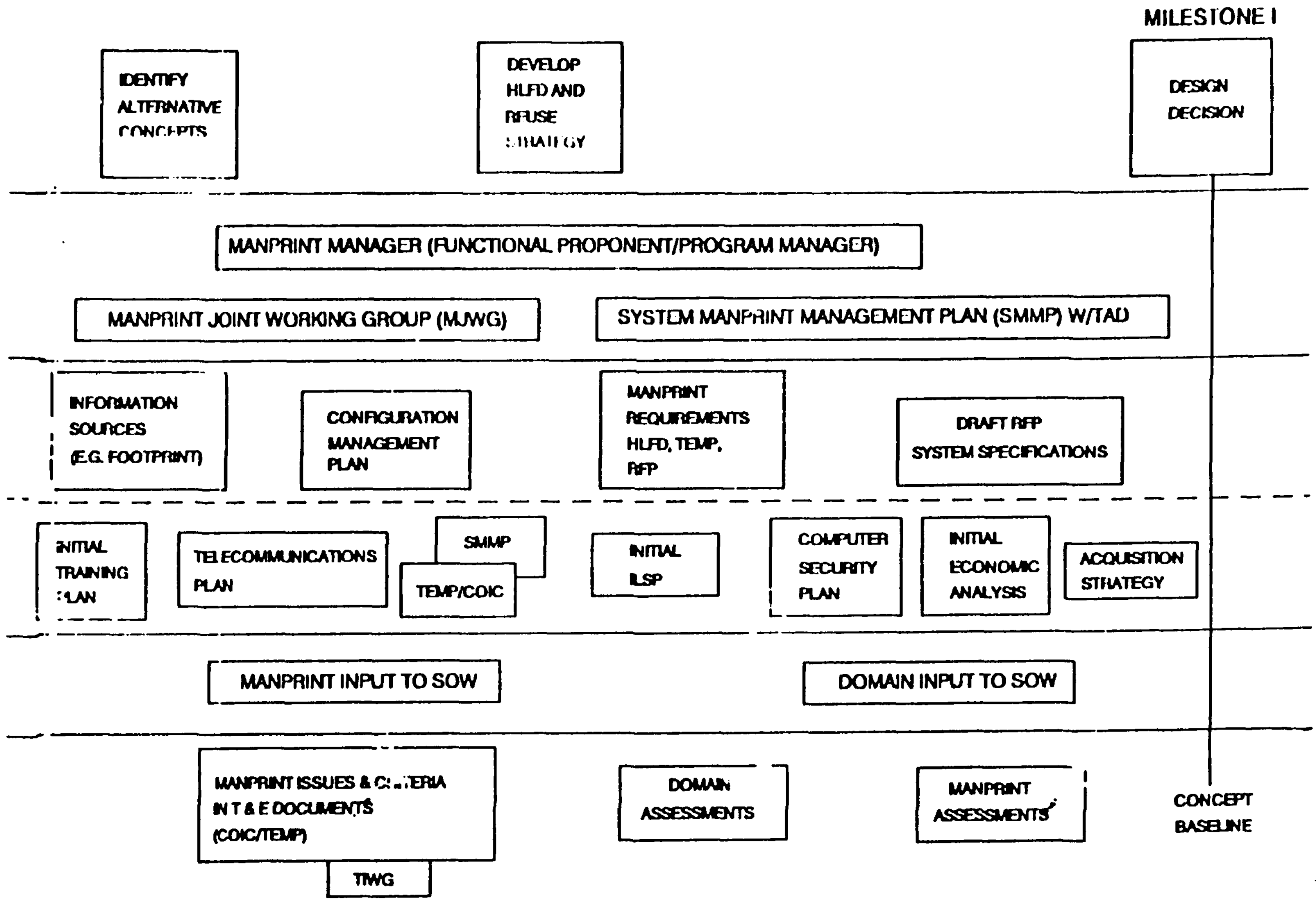
MAISRC HORSEBLANKET

MANPRINT

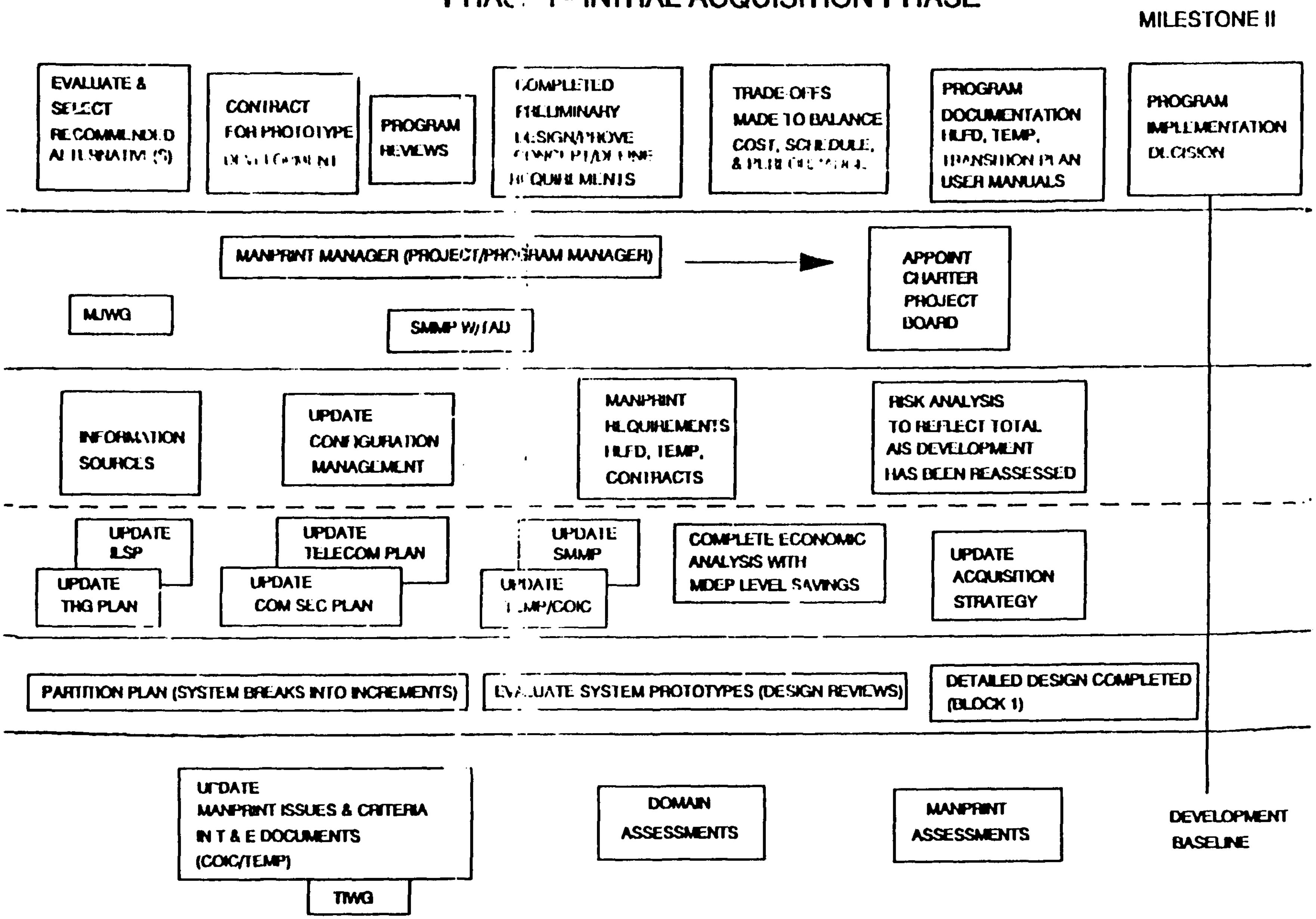
MISSION NEED DETERMINATION



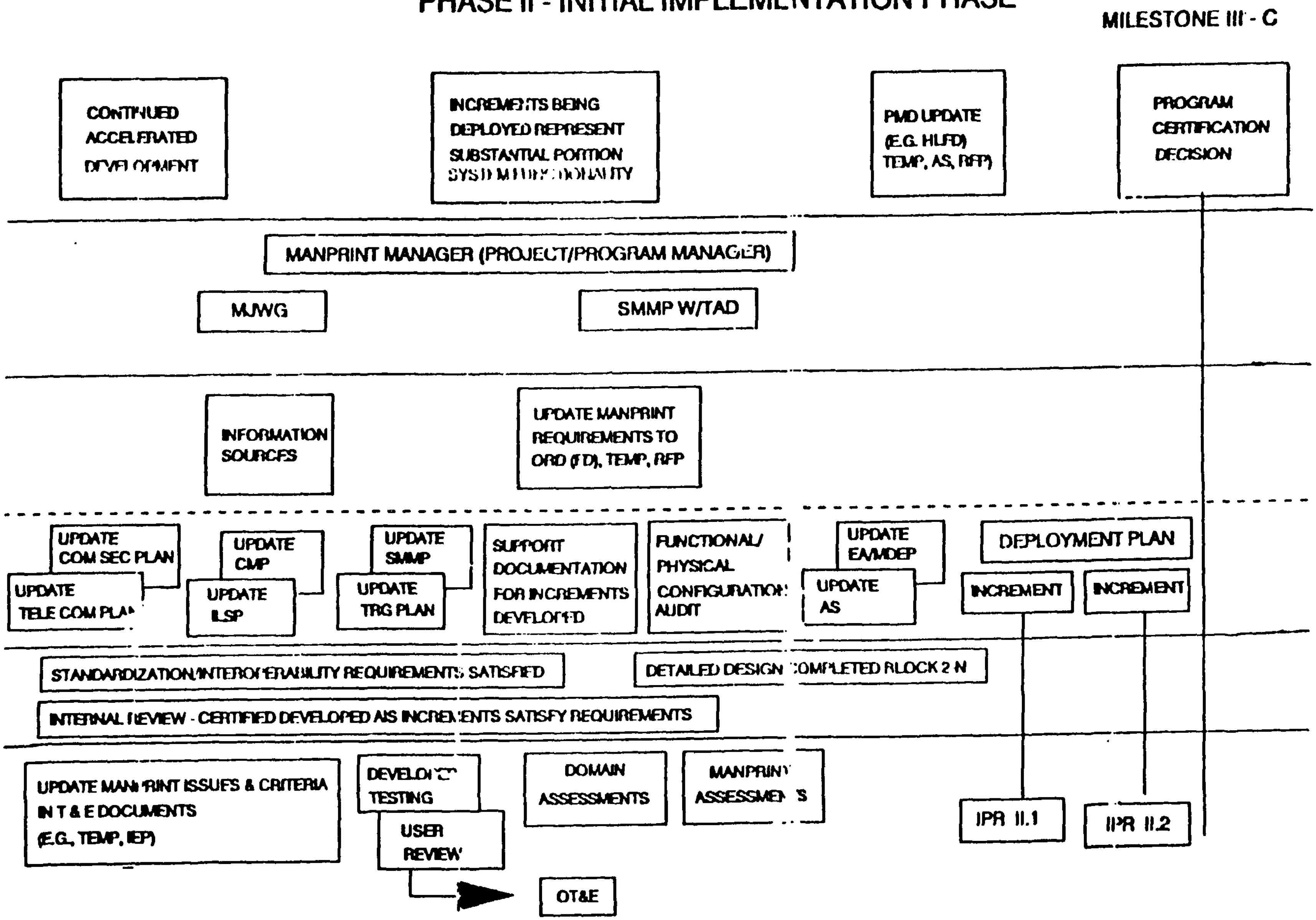
PHASE 0 - CONCEPT EXPLORATION & DEFINITION PHASE



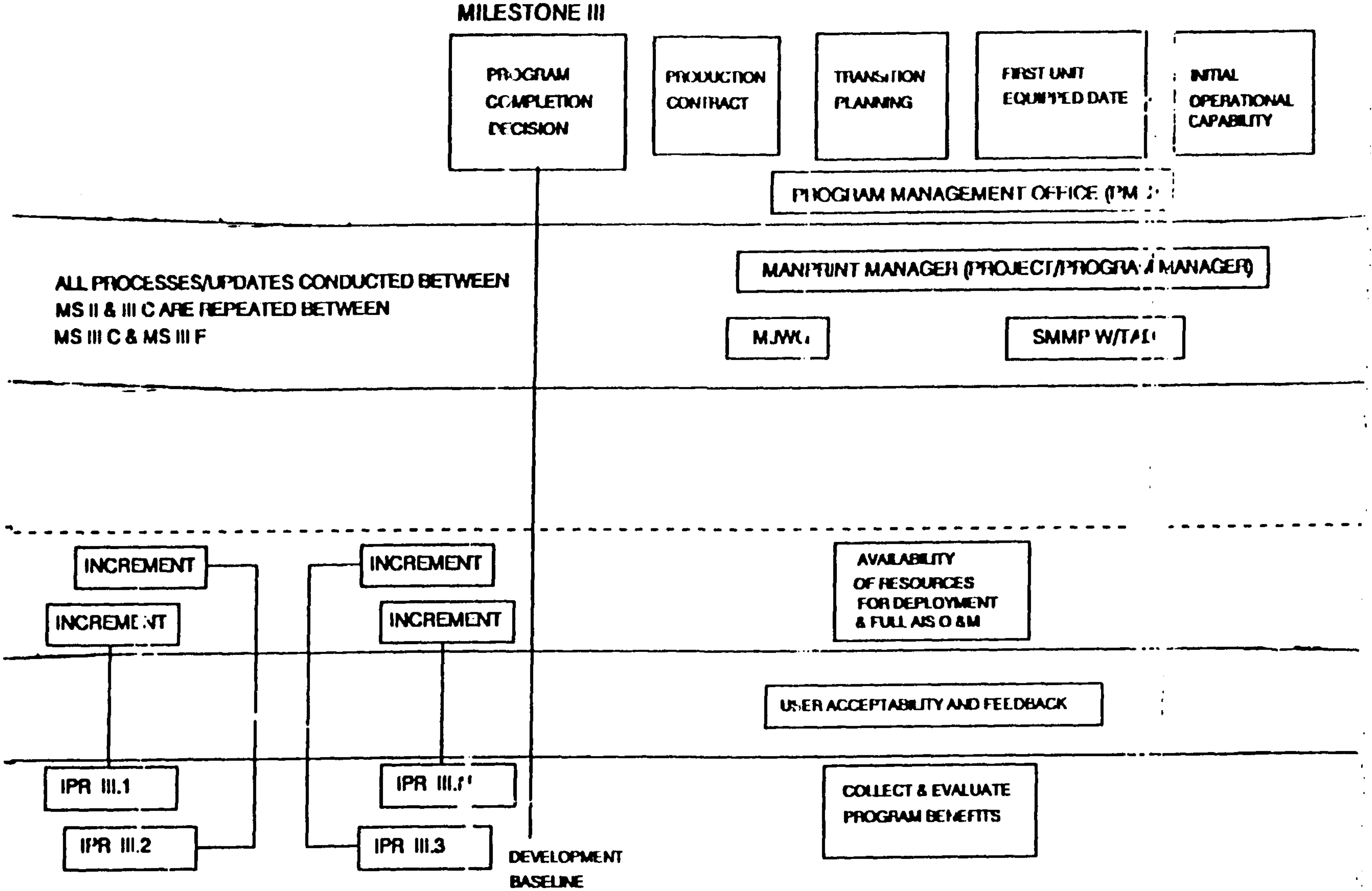
PHASE I - INITIAL ACQUISITION PHASE



PHASE II - INITIAL IMPLEMENTATION PHASE



PHASE III - DEPLOYMENT PHASE



PERSCOM, DCS PI
DIANA LUEKER
DATE: 27 NOV 91

PHASE IV - OPERATIONS AND SUPPORT PHASE

MILESTONE IV

OPERATE AND MAINTAIN AIS

POST DEPLOYMENT AIS OPERATIONAL ASSESSMENT

PLANNING FOR EVOLUTION OF AIS

PLANNING FOR POST-DEPLOYMENT AIS OPERATIONAL ASSESSMENT AT MS IV

MODIFICATION OF MODERNIZATION DECISION

AIS OPERATIONS MANAGER (TERMINATION OF AIS PM'S RESPONSIBILITY)

EVALUATE O & M RESOURCE AVAILABILITY

MANPRINT LESSONS LEARNED

POST FIELDING EARLY COMPARABILITY ANALYSIS (ECA)

*U.S. GOVERNMENT PRINTING OFFICE: 1992-322-554

APPENDIX D

HARDMAN III SURVEY

HARDMAN III User Survey

Date: ______________________________

Organization: ______________________________

Location: ______________________________

Job series/Specialty/MOS: ______________________________

Position Title: ______________________________

Military Education: ______________________________

Civilian Education: ______________________________

1. Describe your current duties and responsibilities:
Include the percentage of time you spend on analysis.

2. Describe your MANPRINT/MPT/COEA analysis and study experience:

3. If you attended the HARDMAN III Training seminar, how well did it:

   a. help you understand the HARDMAN III methodology?

   b. prepare you to conduct analysis with the six modules?

   c. help you to understand what each module does?

4. To your knowledge, does each of the six HARDMAN III modules have a tutorial? If yes, how effective are they in teaching the user the proper steps?

5. If you conduct MANPRINT/MPT/COEA analyses, describe your confidence in your abilities to conduct analyses using HARDMAN III?

6. What costs (money, time, personnel, other resources) do you feel are associated with your current and potential use of HARDMAN III?

7. What benefits (savings of resources) do you feel are (or could be) associated with your current (and potential) use of HARDMAN III?

8. Have you used HARDMAN III to analyze any actual or "notional" Army materiel system? If yes, describe your analysis including modules used and systems analyzed.

9. Have you verified any HARDMAN III algorithms by manipulating any actual MPT data? If yes, describe your analysis including modules used, data analyzed, and the source of your data.

10. Please comment on your perception of the library systems and data built into HARDMAN III.

11. What modifications and enhancements would you recommend for the six software modules?

12. What prerequisites would you recommend for attendance at the training seminar (job requirements, PC knowledge)?

13. What is your assessment of the overall utility of HARDMAN III?

14. What other comments or recommendations do you have to improve HARDMAN III? Use additional sheets as necessary.

Thank you for your assistance.

Optional Name:____________________________Phone:__________________________

APPENDIX E

HARDMAN III SURVEY RESULTS

HARDMAN III SURVEY RESULTS

Name	Activity	Duties / Responsibility	MANPRINT Experience	HARDMAN Training	Tutorial Effectiveness	Confidence In HARDMAN III	Costs Of HARDMAN III	Benefits Of HARDMAN III	Practical Use Of HARDMAN III	Verified HARDMAN	Library Systems	Modifications / Enhancements To Modules	Recommended Prerequisites To Training	Overall Assessment Of HARDMAN III	Comments or Recommendations
Hewitt, G.	Atlantic Research Corporation	Test & Evaluate C3, 25% Analysis	5 Yrs (10+ in OR)	Excellent	N / A	Good	Low	Max	No	No	Needs Resources	User Friendliness Needed	Probability of use	Max	Use numerical scale, market more aggressively
Lipscomb, D	DCD-USAARMS	MANPRINT POC for Ft. Knox	10 Yrs COEA, HARDMAN, ECA	N / A	Not very effective OK, unless you want to construct BCS	Zero, Flawed data base	Will not use	Will not use	Attempted AGS analysis but got lost	No, SPARC module is useless; MAN SEVAL database is incomplete	CCH database is inadequate	Stop work on HARDMAN III	N / A did not attend	Will not use MPT CONS. MAN/PER SEVALS could be useful if database corrected; Takes too long to run analysis	Extensive bucks to update & maintain database. Manpower resources limited
Wittken, J.	DCD USAARMS	ORSA, MANPRINT & ILS 50% at time	SMMP, MPT, COEA	Did not attend	User's manuals are poor	Not certain of database validity	Investment in computer hardware + one full time analyst	If data were valid & procedures clear - might be valuable	No	No, algorithms should be better documented	Incomplete & out of date	More Documentation	1+ year of MANPRINT experience; familiar with IBM 386	HARDMAN III is a liability	Develop HARDMAN III project off guide; validate & update database
McCracken, J.	DCD-USAAVNC	HSI, MMI 5% Analysis	15 Years Workload & Training Analysis	Did not attend	N / A	Don't do analysis	Manpower / training intensive	None	No	No	Manpower & personnel database out of date	MPT database needs to be updated	Very selective and intensive	Design & equipment evaluation tool	Not designed for combat developers; OK for contractors
Kinder, G.	DCD-USAADASCH	Logistics Modeling 50% time	MPT/COEA, TOAs	Did not attend	Good	N / A	Additional workload associated with training time	Pay off would be matching personnel skills vs system requirements	No	No	Data needs updating annually	Not knowledgeable enough to comment	DOS + analytical background, modeling and AI experience	Good potential for integrated MPT vs HARDMAN	None
McAnulty, M.	Anacapa Sciences	Human Factors Research, PHD	FARP Demo using HARDMAN III, SPARC & MAN-SEVAL	All good except T-CON, PER-SEVAL	Adequate but could be improved	Very Good	Can be Labor intensive if new data is needed for BCS	Relative effects on system performance & MPT requirements can be evaluated	Used SPARC & MAN-SEVAL on AH-64 Farp to guage personal performance	Yes, within limits of other models	Limited to models in library	Improve user's manuals, tutorials, workload rating scales, flexibility to build BCS models	PC background, system knowledge	Relatively easy to use, interpretation of results is difficult; all models depend on accuracy of database	Package 3 CON models as a unit, improve library & users' manuals
Reynolds, K.	HEL USAADASCH	ADA Human Factors Engineering 50% on analysis	13 Years HFE 7 years MANPRINT	Fair, but additional time and practice needed	Fair, background in HFE recommended	Highly confident with caveats in 3 & 4	Personnel resources plus cost of additional databases	Capability to do early MPT/HFE tradeoffs could save big bucks	Follow-on to stinger was evaluated using all 6 modules with HFE concerns given priority	Not for MPT data	Need to be expanded/ revised to improve accuracy/ other systems	Included officer & OP test data	Primarily MANPRINT practitioners not neophytes	After improvements, could be best tool available for various types of MAP analyses especially SPARC, MAN SEVAL, PER SEVAL	All system & Human Performance data needs to be verified by SMEs. ARI needs to address Configuration Control, Standardization issues. Across all variables (algorithms, Taxons)

HARDMAN III SURVEY RESULTS
(Continued)

Name	Activity	Duties / Responsibility	MANPRINT Experience	HARDMAN Training	Tutorial Effectiveness	Confidence In HARDMAN III	Costs Of HARDMAN III	Benefits Of HARDMAN III	Practical Use Of HARDMAN III	Verified HARDMAN	Library Systems	Modifications / Enhancements To Modules	Recommended Prerequisites To Training	Overall Assessment Of HARDMAN III	Comments or Recommendations
Adams, T.	MLRS PMO MICOM	Chief Logistics Division	Limited to ILS	Very good for MS Reviews	Very Effective	Good Tool for MGT in MS reviews	1/4 man yr Govt 1/2 -2 man yr for contract support annually	Lower O&S Cost	No	Only in training	Good B/L to begin analysis	More Library Data / Import Interfaces needed	GS-11 minimum, Logistics Management Specialist	Good	More involvement of AMC; availability of software & training
Shaver, C.	TRAC-FBHN	ORA intern	0	Did not attend	OK for teaching software but not for analysis	N / A	Minimal to learn software high for data base currency	None, could be time saver with MODs to software	Tried M-CON with no success	AMSAA data gave different results	Needs to be certified and updated	Make screens & utilities consistent. Certify database,eliminate flowmodel	Computer & DOS; requirement for using software on job	No use for TRADOC; contractors & other Army agencies might benefit	ID users in TRADOC, perform needs analysis, adapt HARDMAN III
Morrison, B.	CASCOM	RAM engineer 40% analysis	Maintenance requirement reliability analysis	Familiarization brief only	N / A	....	....	....	....	SPARC Module is limited	OK, except for use in RAM analyses	Delete SPARC module	....	Good (except for SPARC)	....
Dykhuis, J.	DCS PI	MANPRINT training, 10% analysis	8 Yrs of HCM and ECA analyses	Good as an overview	Good	Fair	Only the time needed to run program	Good Potential for TAD Development	No	No	Limited by storage capability/ cost to update	None	Knowledge of Army MPT Systems	Good for evaluating Operator & Maintainer Personnel	Best used to evaluate designs between MS I & II
Myers, S.	TRAC-FBHN	Combat OPS Analyst	2 Years, 3 COEAs, ORSA MAC I	Overview brief only, but did not prepare you for conducting an analysis	HARDMAN III does not have a tutorial	Unusable, since data has not been certified	Time needed to learn procedures & certification of databases	Certify & Update database. Methodology needs to be fixed to match real-world	M-CON 70% Constraint is Bogus	M-CON has flaws	Poor - data not certified	Needed common language, use of terms. 100% compatability among modules.	Analysis position	Good concept, poor utility	System does not allow for changes in MOSs.